SEPTEMBER 1956

THE WELDING JOURNAL

1956 AWS NATIONAL FALL MEETING

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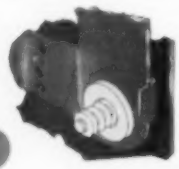

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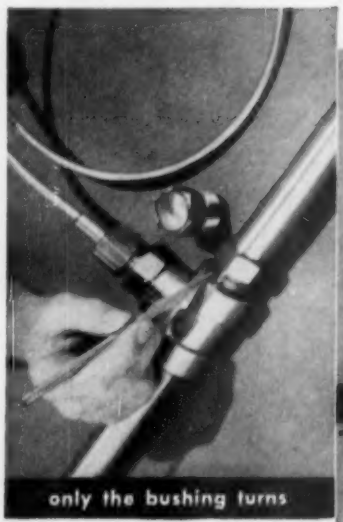

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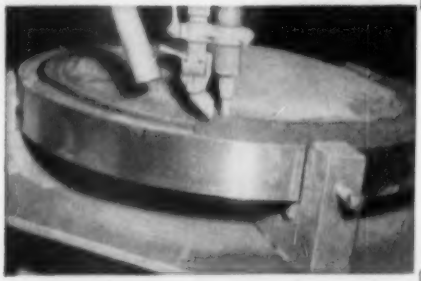

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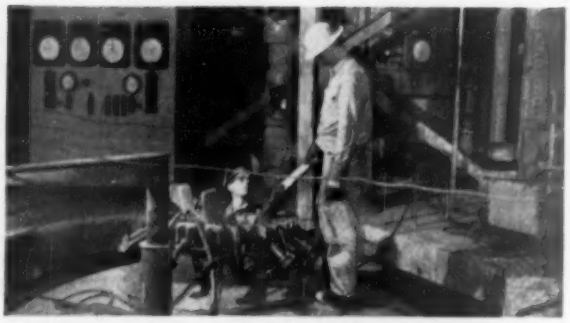

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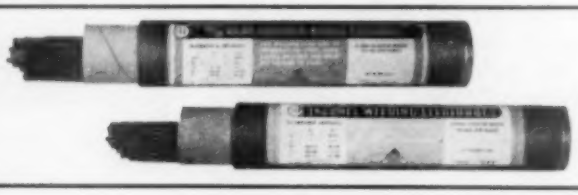

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DECADE OF PROGRESS IN RAILROAD CAR BUILDING

The ten-year period since World War II has been one of substantial improvement in railroad rolling stock. Steam-powered locomotives have been superseded by diesel-powered units. Freight cars have tended to become larger and many have been designed for special uses. There has been a pronounced trend to welded construction in freight cars and the consequent obsolescence of those of riveted design. This change has been inevitable simply because welded construction is stronger and is more suitable for quality controlled mass-production.

Experience in designing, manufacturing and servicing these all-welded cars has shown conclusively that welded car construction is superior to riveted. There are advantages in welded construction for both the manufacturer and the owner. Fabricating costs are lower due to the use of automatic welding equipment, and the accompanying mass-production jigs and fixtures effect further economies. Freight cars of welded construction can, of course, be built without an elaborate production setup and Pullman-Standard still builds some welded or even riveted cars on a customized basis. In such case, however, the maximum economy, through mass-production, cannot be achieved.

There are also qualitative advantages. Welded construction provides a simpler and more effective joint connection and provides greater strength for a given weight. The use of welding eliminates lapped joints where corrosion occurs and provides the more desirable smoother surfaces.

One of the greatest advantages of welded construction that is often overlooked is the quality control made possible by modern production automatic welding equipment. The human element is reduced to a minimum and greater reliability of product is obtained.

This transition from riveted to welded construction is only one of the railroads' many efforts to give improved service at lower cost. Continued research in the welding art by all car builders and suppliers of welding equipment will result in further improvements and economies and go far to assure that our nation's railroads will get the highest quality cars at the lowest possible cost.

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TRANSVERSE CRACKING RESULTING FROM OXYGEN CUTTING

Application of general preheating is reported to reduce to an insignificant rare occurrence transverse cracks on the casting side of a cast-armor, rolled-armor weld joint

BY NORMAN N. BREYER

ABSTRACT. Radiographic discontinuities running transverse to the weld seam were discovered on the casting side of a cast-armor rolled-armor joint. Dye-checking revealed that these cracks were produced on the first oxygen-cut surface by the second oxygen cut during the double-beveling joint preparation. The apparent "welding out" of most of the cracks, when examined radiographically, is a result of the lack of sensitivity of the X-ray inspection method. The depth and location of the cracks on the oxygen-cut surface were metallurgically studied and correlated with the heat-affected zones. The second oxygen cutting operation introduces a temperature gradient along the first oxygen-cut surface. The resistance of the metal on this first oxygen-cut surface to accommodate the dilatometric expansion produces stresses sufficient to cause rupturing. The application of general preheating to eliminate the subject cracking was tried as the fifth attempt at a production solution. This method reduced the transverse cracking to an insignificant rare occurrence.

The Problem

In the pilot stages of the M-48 medium tank production, the Continental Foundry & Machine Division of the Blaw-Knox Co. discovered a cracking condition prevalent in the austenitic welded joints of the hull weldment. Approximately two hundred linear inches of weld are used to place a floor plate in the hull casting. A double-vee full penetration joint is used. This cracking condition was first noted in the routine radio-

Norman N. Breyer is Metallurgist In-Charge-of-Armor, Continental Foundry & Machine Division, Blaw-Knox Co., East Chicago, Ind.

To be presented at 1956 AWS National Fall Meeting in Cleveland, Ohio, October 8–12.

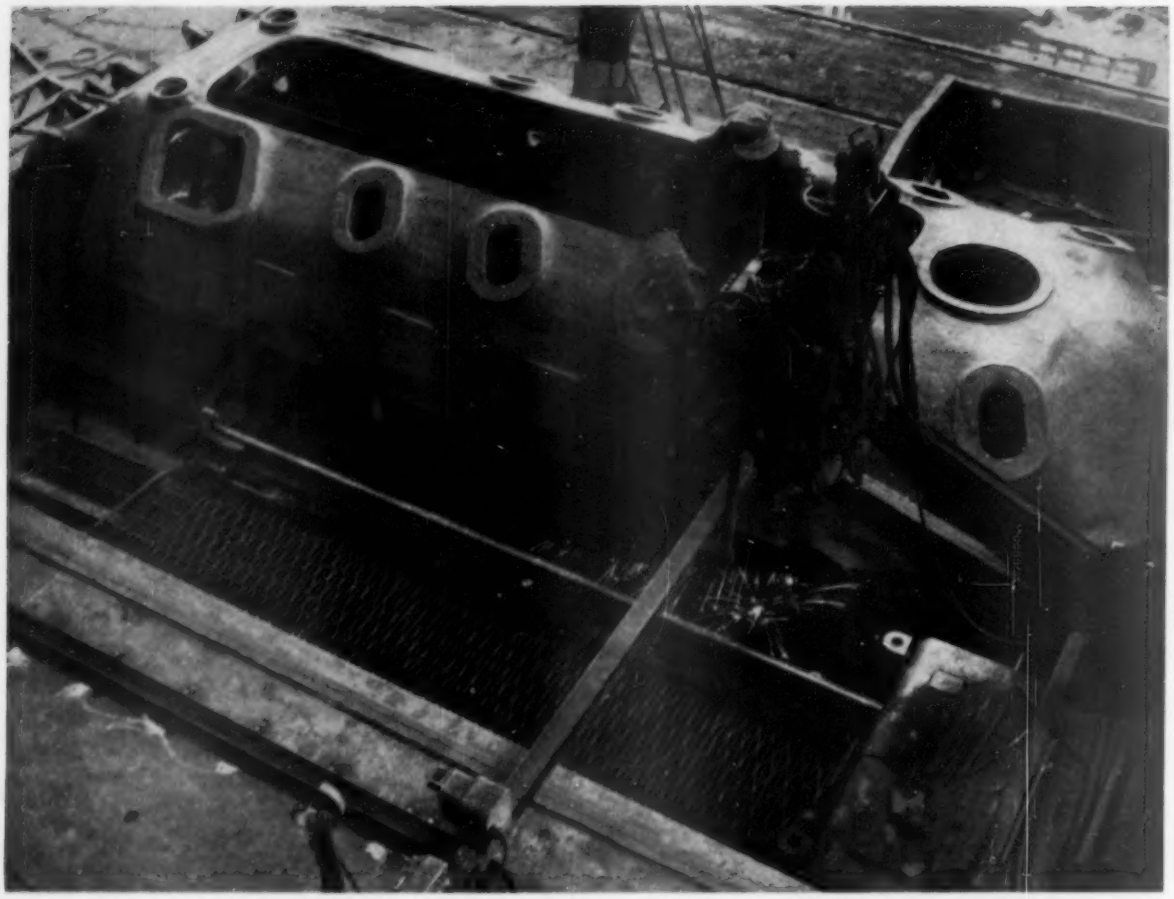


Fig. 1 Oxygen cutting unit scarfing double bevel for floor plate section of hull

graphic examination of these joints and was evidenced as sharp radiographic discontinuities, mainly concentrated on the casting side of the floor plate joint. One-third of the hull units fabricated and machined at East Chicago were cast by the General Steel Casting Corp. The armor heats of this supplier, used for making these one-piece hulls, were made in basic open-hearth furnaces and were alloyed with $2^1/_2\%$ chromium and $^1/_2\%$ molybdenum. The nominal composition of these hull units can be noted in Table 1. One-half of the monthly production of hulls, also of the one-piece casting design, were poured at our Coraopolis plant. The remaining hull units cast at our East Chicago plant were comprised of four main castings; a front hull casting, a left side casting, a right side casting and a rear hull casting. These four pieces were welded together and then treated as an integral hull unit. The composition of armor for these East Chicago units and also for the Coraopolis hull units, both of which were poured from acid open-hearth furnaces, can also be noted on Table 1.

The normal procedure for preparing the casting side of the weld joint to receive the floor plate subassembly employs an oxygen cutting fixture in which the excess stock is removed to provide a double bevel. A commercial oxygen cutting machine is utilized. The rate of travel of the cutting tip is approximately 7 to 8 ipm.

Table 1—Chemical Composition of the Two Armor Types

Source	*C*	*Mn*	*Si*	*S*	*P*	*Cr*	*Ni*	*Mo*
General Steel*	0.23	0.50	0.20	0.050	0.050	2.15	...	0.45
Casting Corp.	0.33	0.80	0.70	Max	Max	2.85	...	0.65
Continental Foundry†	0.23	0.80	0.20	0.050	0.050	0.70	0.70	0.40
and Machine Division	0.33	1.30	0.70	Max	Max	1.20	1.40	0.60

* Heats made in basic open-hearth furnaces.
† Heats made in acid open-hearth furnaces.

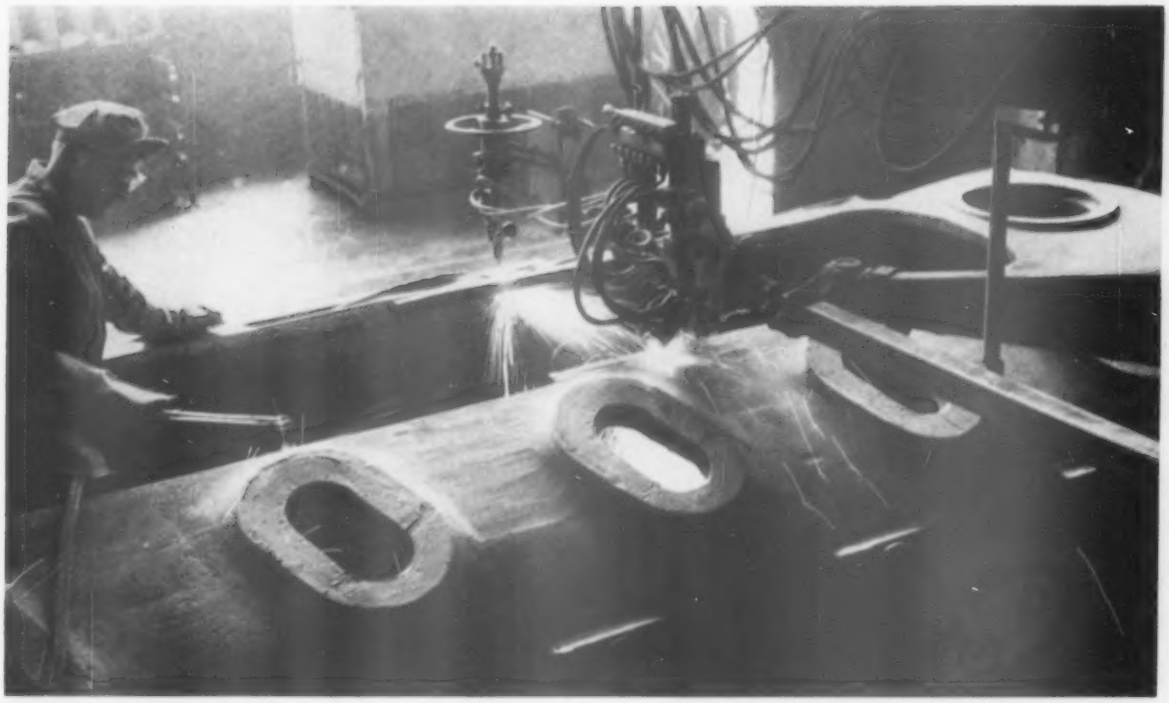


Fig. 2 Close-up view showing oxygen cutting operation. Simultaneous scarfing on both sides

Fig. 3 Radiographic film showing transverse cracks (X6). Light area is casting side. Dark area is weld metal

The acetylene pressure is 7 psi. The primary oxygen is 30 psi while the cutting oxygen is 55 psi. Figure 1 is a photographic view showing the unit being utilized for the scarfing of the floor plate section. Figure 2 is a close-up photograph which reveals that the operation involves simultaneous cutting of one bevel on each side.

In the course of reviewing radiographic films of the floor plate, the images of the transverse cracks were noted. These cracks did not run completely across the weld metal, but seemed to be concentrated on the casting side of the weld. The typical appearance of these transverse cracks can be noted in Fig. 3. Transverse cracks were present in all three types of hull units mentioned above. It should be remembered that two

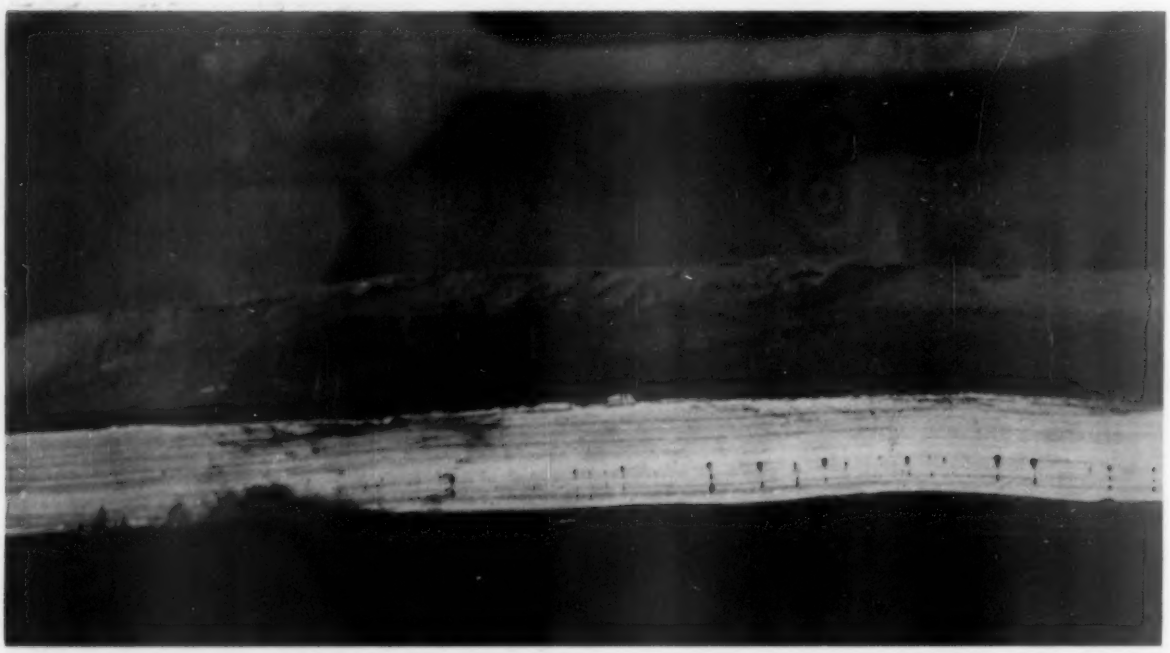


Fig. 4 Dye-checked bevel edge. Cracks appear on first cut side. Note scribe marks on casting surface denoting each crack

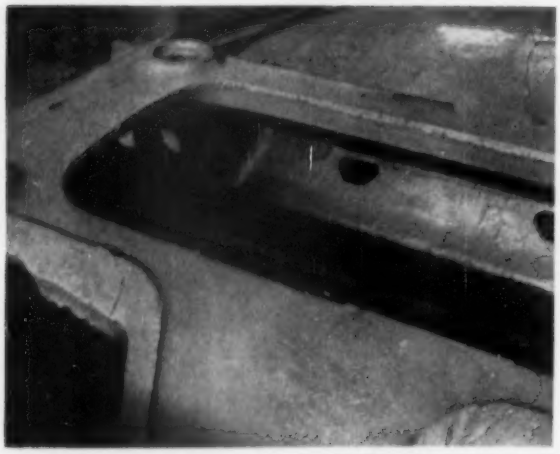


Fig. 5 Floor plate area of casting showing rib

Fig. 6 First beveling cut on ribbed hulls. Note outward cant of torches

different compositions, two different melting practices and three melting sources were utilized for the hull units. All hulls exhibited these cracks in varying degree.

Upon further investigation into the transverse crack situation, it was determined that the transverse cracks were present after the oxygen cutting operation. The number of cracks per hull varied from as few as a dozen to over four hundred. These surface checks could not be seen with the naked eye; however, dye-checking immediately revealed their presence. It was evident, after reviewing the visual appearance of these cracks when exposed by the dye-checking method, that ruptures occurred only on the surface beveled by the *first* torch. This can be noted in Fig. 4. Only in rare instances did the edge cut by the second torch show a few transverse cracks. Incidentally, Fig. 4 shows scribe marks which were placed on the casting to locate each crack for an experiment which will be detailed in the next section of the report. It was further determined on certain hulls which were allowed to cool to room temperature after the first bevel cut that no transverse cracks were revealed by dye-checking. Dye-checking this first cut surface again after the second bevel cut indicated the presence of cracks.

Figure 8 is a sketch showing the respective oxygen cutting procedures which were utilized for beveling the floor section of the hulls made by both producers. At the beginning of the program the one-piece hull units made by General Steel incorporated a reinforcing rib in the floor plate section (see Fig. 5) which was removed during the scarfing operation. Because of the rib, these hulls were cut with a sequence the reverse of that used for the other hulls. The second cut for the ribbed units was made from the outside casting surface through

the casting to the first cut bevel surface, so as to create the joint apex. On this reverse cutting sequence, the cutting flame does not play on the apex. Figure 6 shows the first bevel cut employing the reverse sequence. In general, fewer cracks were detected on these hulls than on hulls cast from the Mn-Cr-Ni-Mo analysis. The dye-checking operation reveals the cracks and it can be noted that they are on the portion of the bevel corresponding to the inside of the vehicle (see Fig. 7). However, since the cutting sequence is reversed they still appear on the first oxygen cut surface. The occurrence of the cracks on both hull types is indicated schematically in Fig. 8. Another interesting phenomenon that became evident in the course of the investigation was that these transverse cracks did not start at the apex but were spaced approximately $^1/_8$ in. from the apex. This factor was important to an understanding of and to a solution to the problem of eliminating transverse cracks.

When these cracks were found, a procedure of dye-checking 100% of the casting floor plate bevel edges was established. Each crack is indicated by a thin dye line.

Fig. 7 Dye-checked beveled edge of hull unit after removal of rib

Large bleed spots at either extremity of the crack indication can be noted. This bleed condition originally created the feeling that cracks may have started at location points of microshrink. The author believes, after working closely with this problem and examining many such dye-checked surfaces, that capillary action is responsible for this phenomenon. The bleed spots are the physical extremities of the crack. The adjacent walls of the crack at the extremities are very close together. They can be assumed to diverge and leave an open gap at the center portion of the crack. The red dye solution applied to surface fills the crack and the subsequent application of the developer solution "draws" the red dye out of the crack. Since the gap is very narrow at the crack extremities the capillary action is stronger at these points. The solution, therefore, shows more intensely at the extremity locations. The author feels that bleed spots are a natural phenomenon and do not thus point to inherent casting deficiencies or weaknesses.

The original expedient to correct this condition was to remove each crack by grinding. The void was welded with stainless-steel electrodes and the repair ground smooth. This procedure involved considerable expense, but did not solve the basic problem. We wondered how many cracks were not removed because they were not seen and we also wondered what detrimental effects this highly stressed edge would have on subsequent welding. Questions such as whether or not the cracks would weld out provoked considerable discussion among some of our personnel.

Apparent Welding Out of Transverse Cracks

We wondered if these small cracks would not weld out when the austenitic electrode was applied to the oxygen-cut edge when welding the floor plate in place. To answer this question an experiment was undertaken. The hull which was cut, and the edge of which is shown in Fig. 4, was carefully marked with scribe marks on the cast surface indicating the location point of each transverse crack. No repairs were made on this oxygen-cut edge. The floor plate was fitted and the joint was welded. A 100% radiographic examination was made utilizing a quarter million volt X-ray unit and fine-grained film. The films were carefully read and sketches were made indicating the location of each radiographically visible crack. There were only 19 transverse cracks detected radiographically. Seven of these matched the previously located dye-checked positions. (Table 2 is a correlation of the data obtained from this experiment). One of the things about which we were seriously concerned was that 12 new cracks had appeared. The immediate question from the production personnel was—"What has happened to the other 203 cracks which were originally located on the oxygen cut surface?" The answer to this problem is apparent when one reflects on the technical limitations of X-ray examination techniques. The normal requirement in any radiographing is to obtain approximately 2% sensitivity. An X-ray unit will normally show any defect which varies by more than 2% from the thickness of adjacent

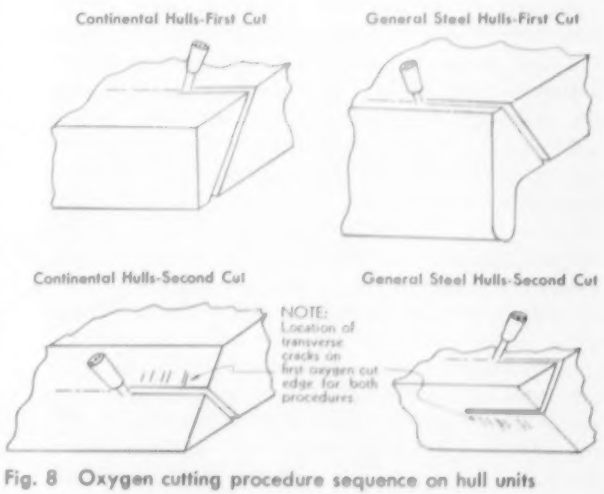

Continental Hulls-First Cut
General Steel Hulls-First Cut
Continental Hulls-Second Cut
General Steel Hulls-Second Cut
NOTE:
Location of transverse cracks on first oxygen cut edge for both procedures

Fig. 8 Oxygen cutting procedure sequence on hull units

Table 2—Correlation of Transverse Cracks Detected Radiographically to Cracks Located Using Dye Check on Oxygen Cut Edge

Radiographic position chart number	*Number of dye check transverse cracks (center-punched for location)*	*Radiographic transverse cracks matching dye checked locations*	*Radiographic transverse cracks not matching dye-checked locations*
1	23	0	0
2	19	0	0
3	23	0	0
4	9	0	0
5	12	1	1
6	0	0	0
7	2	0	0
8	0	0	0
9	3	0	5
10	0	0	0
11	5	0	0
12	0	0	0
13	4	0	0
14	0	0	2
15	8	0	0
16	0	0	0
17	9	6	2
18	2	0	0
19	1	0	1
20	14	0	0
21	23	0	0
22	25	0	1
23	28	0	0
Totals	210	7	12

material. In those cases in which the beam from the X-ray unit penetrates a crack at an obliquity there is no transmission of the image to the film since there is no thickness variation. Thus only cracks which are directly in line with a primary X-ray beam will be shown on the radiographic film. In our particular case, the sensitivity of the X-ray unit and random orientation of the head in relationship to the cracks made it difficult to detect more than 7 of 210 original cracks. We cannot say the remainder were welded out.

Nature of the Crack

It was easily seen, upon dye-checking, that the approximate distance from the apex to the portion of the crack nearest the apex was almost the same for all transverse cracks on a given hull (see Figs. 4 and 7). We had numerous unanswered questions as to the nature of these cracks. We wanted to know whether the cracks initiated at a weak spot in the casting such as a shrink zone (this was suggested as a possible source of the cracks since the previous explanation of the bleed spots was not universally accepted). We also wished to know how deep each crack was. At first, it was further questioned whether or not the presence of such small discontinuities was insignificant or whether the discontinuities were potential crack starters. Transverse cracks similar to the type which we had discovered radiographically had been reported by other fabricators on numerous occasions at Ordnance Committee Meetings. In subsequent correspondence with the Detroit Arsenal the author was informed that a careful and detailed study of the propagation of such transverse cracks had been made. On vehicles which had been carefully earmarked it was found that these small transverse cracks extended with the transition of time and/or vehicle service. It had also been experimentally noted that small transverse cracks barely detectable with radiographs on $1^1/_2$-in. welded ballistic test plates (unfired) propagate and become very apparent with the transition of time.

An experiment to examine the crack characteristics was carried out. A small "pie section" from the oxygen-cut bevel of a hull (shown in Fig. 4) was removed with a hand grinder. It was exceedingly difficult after removing this section to locate the transverse cracks which we originally knew, because of dye-checking, to be there. A 10× hand magnifier still did not reveal the transverse cracks. Apparently the longitudinal stress along the oxygen-cut edge was released and these minute cracks were allowed to close shut. This is a definite indication of the residual stresses present after oxygen cutting. Dye-checking did not relocate the cracks. A metallographic sample was prepared by polishing the first oxygen cut surface. It was realized that the metallographic surface thus obtained would be below that of the original cut surface. The specimen was polished, etched, and photomicrographs at 50× were made. A composite picture looking down at the cracks can be noted on Fig. 9. In the metallographic viewing of this sample two points of interest were examined: (1) The crack extremity, i.e., the portion nearest the apex, was closely examined. The microstructural examination at the crack extremity nearest the apex does not reveal any evidence of microshrinkage or other contributing causes. This crack extremity is not felt to be the origin of the crack, as will be spelled out in the section on "Stress Conditions Causing Cracks." (2) A small area where the crack ran through some inclusions was also examined and was photographed at 500× (see Fig. 9). The crack running through the inclusions is shown for the academic interest rather than to point to a contributing cause. The photomicrographs of Fig. 9 are, naturally, planar whereas the crack is three dimensional. The small sketch in the lower left-hand corner of Fig. 9 details the location of the metallographically polished plane. The linear dimensions indicated on the composite photograph in the upper portion of this figure are not true oxygen-cut surface measurements because of the metal removal in the polishing operation. It can be noted in this figure, however, that the crack starts to the right or the side of the heat-affected zone away from the apex.

Since the investigation of the sample from the pie section was planar, we still did not know the depth and actual shape of the crack. In order to check this, a simple experiment was carried out. A scrapped 2 in. thick ballistic plate of the chromium molybdenum composition was oxygen cut employing our standard cutting procedure. Dye-checking immediately after the beveling revealed the presence of a few transverse cracks. These cracks were very similar in appearance to those

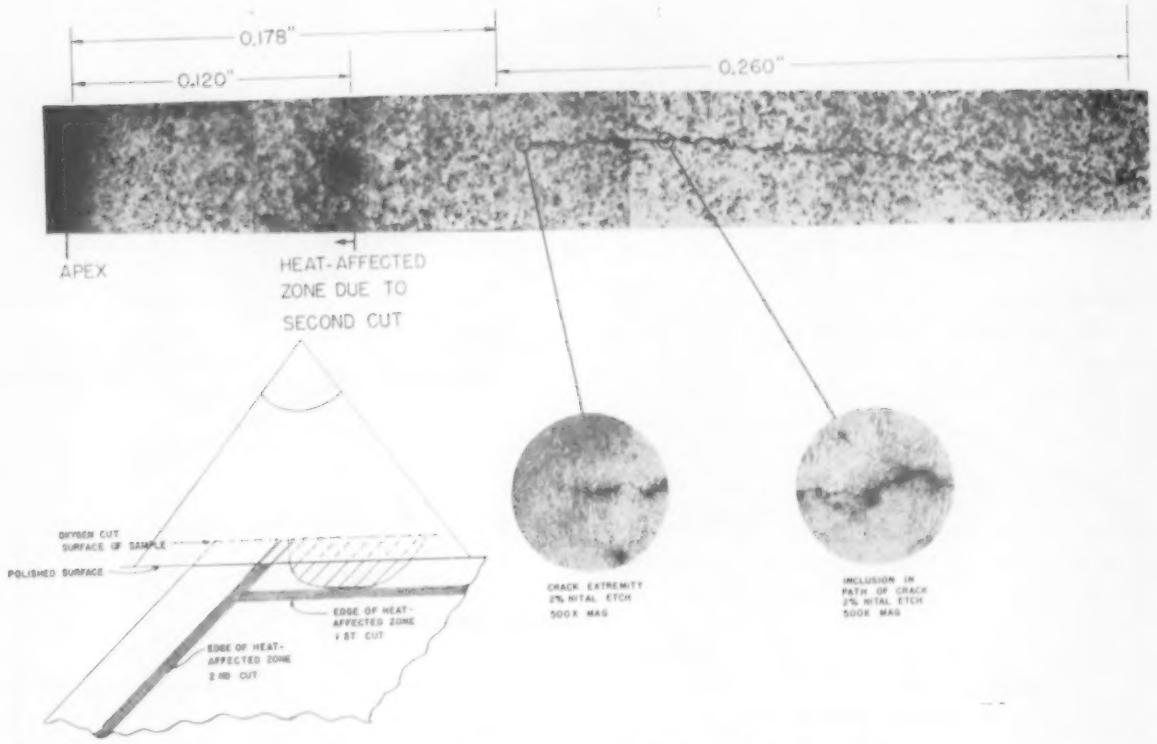

0.178"
0.120"
0.260"
APEX
HEAT-AFFECTED ZONE DUE TO SECOND CUT
OXYGEN CUT SURFACE OF SAMPLE
POLISHED SURFACE
EDGE OF HEAT-AFFECTED ZONE 1 ST CUT
EDGE OF HEAT-AFFECTED ZONE 2 ND CUT
CRACK EXTREMITY 2% NITAL ETCH 500X MAG
INCLUSION IN PATH OF CRACK 2% NITAL ETCH 500X MAG

Fig. 9 Composite photomicrograph showing relationship of crack to oxygen-cut apex (X50)

found after oxygen cutting hull units. The locations of the transverse cracks were carefully marked so as to locate them on the oxygen-cut edge after the dye-checking was removed. A large metallurgical sample approximately 10 in. long and $^5/_8$ in. thick was carefully oxygen cut so as to incorporate the beveled edge exhibiting cracking. The excess stock behind this first oxygen-cut surface was carefully ground from the sample until the material behind the first bevel cut was only $^1/_4$ in. thick.

This simple beam was subjected to an experiment. A solution utilizing India ink mixed with a photographic wetting agent was prepared. The beam, with the known crack locations, was supported on both ends in a bend test fixture of a tensile machine. The movable head was brought down so as to slightly deflect this sample. The load indication on the weighing mechanism of the machine indicated a negligible load. At this point the oxygen-cut surface which was on the tension side of the beam was swabbed with the India ink solution. After allowing sufficient time for the ink used in the staining operation to dry, the bend load was continued until the sample failed. Visual investigation of the fracture surface revealed that the India ink had soaked into the crack in a manner similar to a dye penetrant and had stained the transverse crack through which the part failed. A check of the original marking on the oxygen-cut surface also corroborated the fact that fracture had taken place through one of the original transverse cracks. The depth and length of the crack were easily determined. A photograph of the India ink stained surface and a corresponding sketch of the location of the sample from the beveled original plate are shown on Fig. 10. It can be seen on this figure that the crack is spaced approximately $^1/_8$ in. away from the apex. The crack length is 0.167 in. This length is smaller than that which we had experienced in the beveling of hull castings. However, the stress conditions for this edge are certainly different from those on a one-piece or fabricated hull. The depth of the crack, as can be noted in Fig. 10 is 0.068 in. That this is significant will be revealed later in this report.

Stress Conditions Causing Cracks

In the cutting of either bevel, a zone from the oxygen-cut surface into the base material will range from the cutting temperature of approximately 2500° F down to the preheat temperature of the plate. This 2500° F temperature is estimated from a study of the phase diagram for the system iron–oxygen.[2] In the cutting operation the oxyacetylene flame preheats the work to approximately 1500° F. When the cutting oxygen is turned on, Wüstite of slightly over 23% O is formed by the diffusion of oxygen into the iron. This reaction can be written:

$$Fe + {}^1/_2X\ O_2 \rightarrow FeO_x(\text{Wustite}) + \Delta H \qquad (66{,}500\ \text{cal})$$

The heat of reaction raises the temperature of the Wüstite to the eutectic temperature of 2500° F. The eutectic liquid containing 22.8% oxygen (approxi-

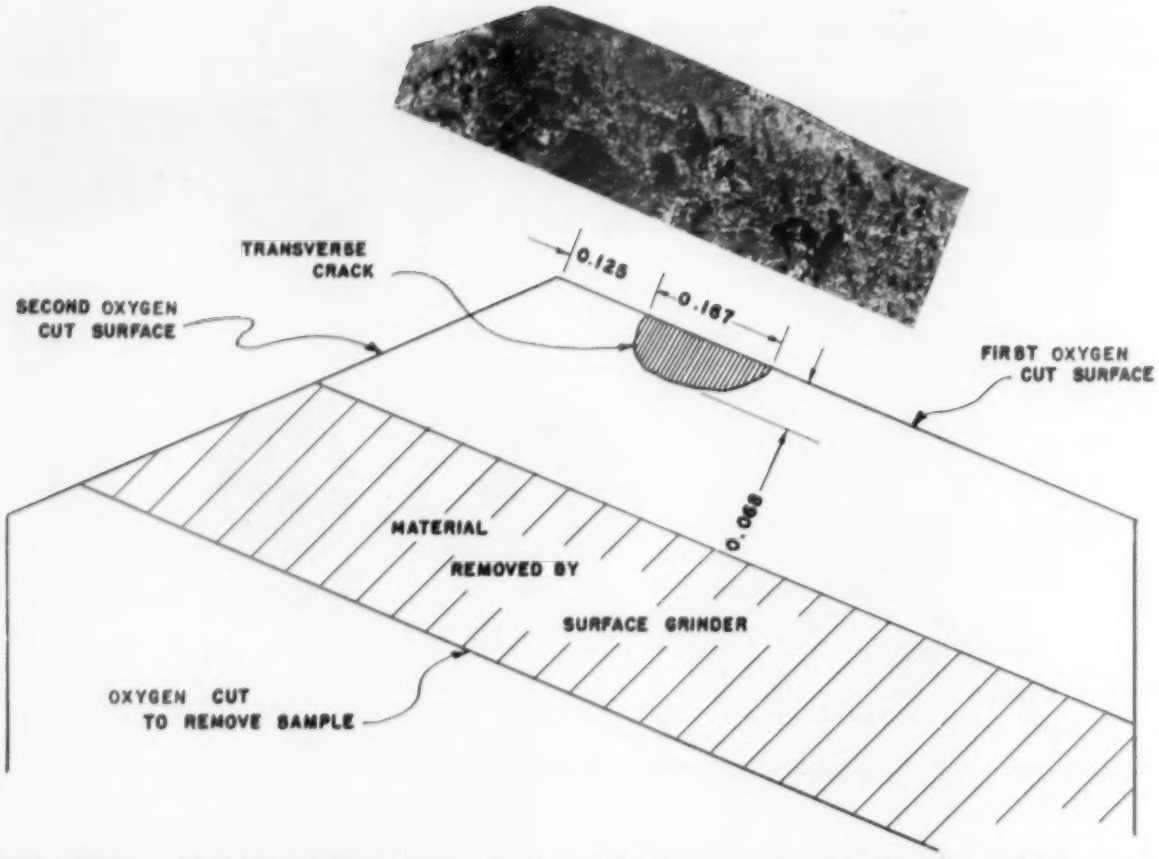


Fig. 10 Photograph with India ink stain in transverse crack. Sketch showing location of specimen and crack location (X6)

mately 200° below the melting point of pure iron) is actually pushed downward by the cutting oxygen stream and forms the smooth walls of the cut. For alloy steel, shifts in temperature and compositions are expected; but, essentially this mechanism should be followed.* The melting temperature of the kerf is 2500° F (neglecting alloying elements in the steel) and this must also be the interface temperature. That portion of the first cut surface which ranged from 2500° F down to the A_3 critical temperature of approximately 1400° F will have transformed, on this high hardenability steel, to a martensitic structure immediately after the cutting torch has passed. This layer is extremely hard and correspondingly brittle. During the *second bevel cut* a related metallurgical phenomenon takes place along the *first bevel surface* (as well as on and below the second bevel surface). The portion above 1400° F transforms to austenite. Because of the high temperature and the face-centered cubic lattice of austenite, this phase is very ductile. That material away from the apex which is just below 1400° F will be subjected only to

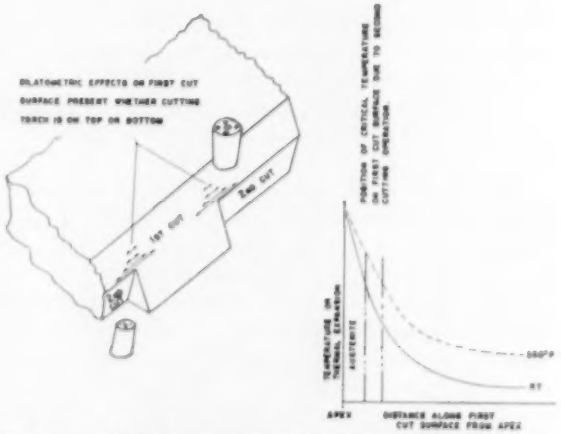

DILATOMETRIC EFFECTS ON FIRST CUT SURFACE PRESENT WHETHER CUTTING TORCH IS ON TOP OR BOTTOM
2nd CUT
1st CUT
APEX
DISTANCE ALONG FIRST CUT SURFACE FROM APEX

Fig. 11 Schematic diagram indicating qualitative stresses introduced on first oxygen-cut edge by second cutting operation

flash tempering treatments which tend to soften it. However, because of the high rate of travel, approximately 7½ ipm, this time-temperature phenomenon is not too extensive and the original martensitic hardness remains relatively unchanged.

Along with the phase and tempering phenomena, the well-known dilatometric changes take place. Linear

* The mechanism indicated above explains the occurrence of free iron supposedly washed out of the cut as unconsumed or metallic iron. The phase diagram of Darken and Gurry[3] clearly shows that the eutectic liquid solidifies upon cooling through the reaction temperature, forming a small amount of free iron and the majority Wüstite. The Wüstite undergoes a eutectoid reaction at 1040° F and forms the Fe_3O_4 and approximately 16% free iron. Thus the Fe_3O_4 and at least some of the free iron are produced when the slag formed in the kerf cools to a black mass on the floor.

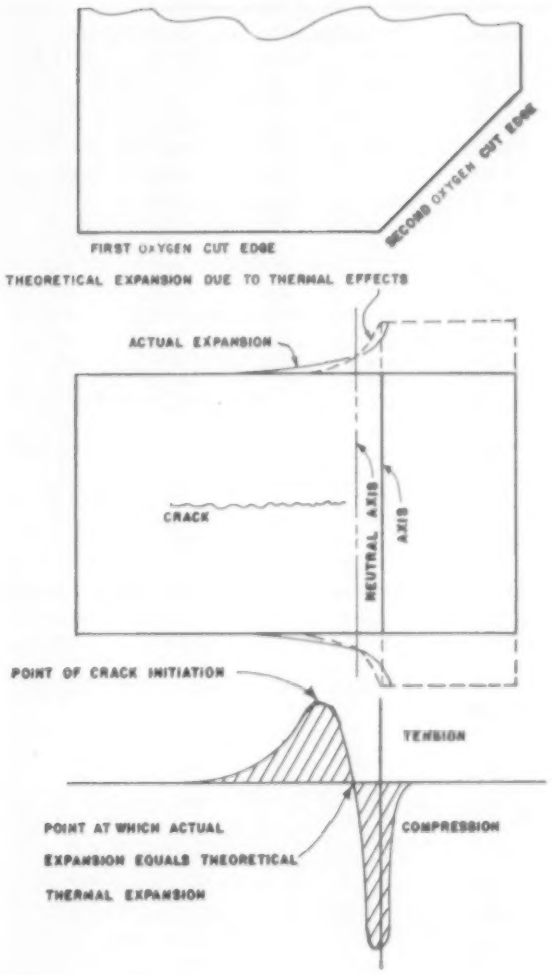


Fig. 12 Stress origin causing cracks

expansions reflecting a coefficient of expansion in the neighborhood of 7.8 × 10^{-6} in./in./° F take place. Since the thermal expansion is proportional to the temperature it can be seen that the apex, if unrestricted by the continuous nature of the metal, would expand the most and the rest of the material would expand so as to reflect the temperature gradient. The solid line in the sketch in the lower right-hand corner of Fig. 11 is the temperature distribution for the condition existing when no preheat has been employed. The dotted line is for a 350° F preheat sample. The apex point is at the cutting temperature and a rapid fall off from this cutting temperature occurs as we move away from the apex along the first oxygen-cut surface. In the upper left of Fig. 11 a diagram schematically shows the expansion by the length of the arrow. Since thermal gradient on the first oxygen-cut surface exists whether the cutting torch is on the top or on the bottom in making the second cut, the expansion along the first cut surface is present in both procedures.

Figure 12 indicates the origin of the stress effects causing transverse cracks. If the first cut surface could be considered as infinitely thin layers of metal unrestricted by adjacent material, the expansion would only reflect the thermal effects and in the cutting operation dilatometric expansions would take place as indicated by the dotted line in the center sketch. However, the influence of adjacent material results in a restraining effect on the apex expansion. The exact degree of restraint is not known. From the orientation of the cracks it is assumed that the major stress is in the direction of the cutting torch travel. The stress in the other two directions are considered to be lesser contributing factors and are neglected for simplicity of explanation. From the location of the cracks which are concentrated near the oxygen-cut apex, we know it is not correct to assume that the cross sections through both oxygen-cut surfaces are planar near the cutting torch, but that there is local bulging which introduces stress concentrations at the apex area. The stress, σ, is a function of the difference between the theoretical expansion and the actual expansion and can be developed as follows:

$$\varepsilon = \varepsilon_{th} - \varepsilon_{act} \tag{1}$$

where:
ε_{th} = Theoretical thermal expansion, in./in.
ε_{act} = Actual linear expansion, in./in.

$$\varepsilon_{th} = \theta \alpha \tag{2}$$

where:
$\theta = T_m - T$, or
= Temperature at the apex, ° F minus the temperature at any point away from the apex, ° F
α = Coefficient of thermal expansion, in./in./° F

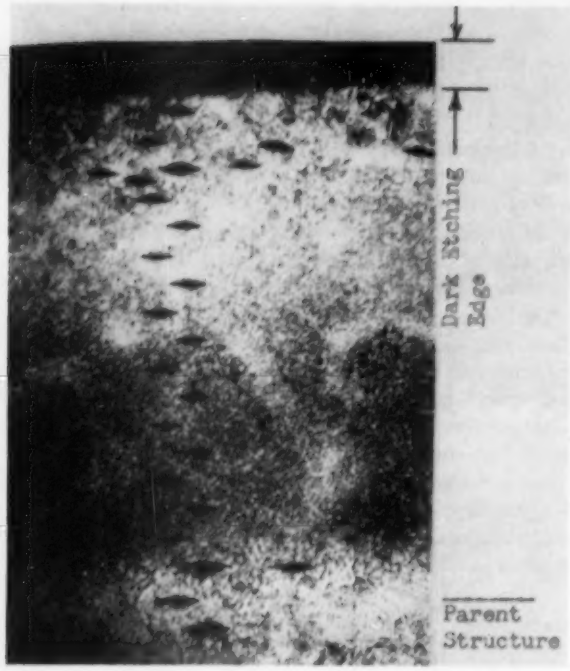
$$\sigma = E\varepsilon \tag{3}$$

where:
E = Young's Modulus

It must be remembered for a temperature variation from the apex along the first cut surface Young's Modulus is not a constant but is a function of temperature. It is permissible to use the elastic laws only for the portion of the metal on the untempered martensite side since here the ultimate strength and the yield point are nearly the same. Calculations of the stress are not simple since Hooke's Law does not apply to the ductile portion of the metal stressed beyond the elastic region. In addition, the degree of restraint of the material near the torch to accommodate the thermal expansion is not known. However, the stress relationship will be such that the apex area will be in compression and the material away from the apex will be in tension and these two forces are equal and opposite. This condition follows from the equation of statics:

$$\int \sigma da = 0 \tag{4}$$

which states that the internal forces over a cross section must equal zero. The ability to flow of austenitic material (above the yield point) will tend to relieve some of the compressive stresses and correspondingly reduce the opposing tensile forces. The neutral axis or line along which the stress is zero will be at the point where the actual expansion equals the theoretical thermal expansion. Below the 1400° F point the untempered martensite is in linear tension. The inability of untempered martensite to deform permits the tensile



Microstructure of cross-sectional sample for 350° F first cut edge. Note two shades of main heat-affected zone. 2% Nital × 50

Distance, mm	*Room Temperature*		*350° F Preheat*	
	1st cut	*2nd cut*	*1st cut*	*2nd cut*
0.00	...	...	...	...
0.10	633	726	470	633
0.20	599	528	494	574
0.30	633	588	421	478
0.40	588	548	494	486
0.50	511	511	520	503
0.60	455	528	402	503
0.70	538	520	455	520
0.80	528	610	494	588
0.90	578	528	428	486
1.00	548	511	470	441
1.10	599	448	434	415
1.20	441	503	421	338
1.30	486	...	415	379
1.40	511	448	441	338
1.50	428	415	402	296
1.60	374	334	396	276
1.70	271	320	428	274
1.80	281	325	434	249
1.90	292	292	308	...
2.00	285	289	347	...
Dark etching edge	0.18 mm	0.14 mm	0.23 mm	0.24 mm
Total heat-affected zone	0.063 in.	0.061 in.	0.079 in.	0.057 in.

Fig. 13 Knoop hardness determinations on first and second bevel cuts

stresses (in the direction of the cutting torches) to approach and pass the yield point of this brittle material.* When the yield point is reached the inability to accommodate the apex expansion necessitates the rupture of the untempered martensite. Thus origin of transverse cracks on the first cut surface due to the second bevel cutting operation can be seen. In the lower portion of Fig. 12, a schematic representation of the stress condition has been indicated. The crack should proceed in both directions from the maximum stress point. The stress is proportional to the difference in expansion of the various zones of the actual to the theoretical thermal expansion length. It can be seen from the above reasoning, however, that the combination of thermal gradient and restraining influences of material introduces the stress condition which results in rupture of the brittle martensite on the first oxygen-cut surface. The thermal gradient and stress will be present whether cutting is done from the top or bottom position. This explains the origin of cracks on hulls made using two different melting practices and cut using two different procedures.

Relationship Between Heat-Affected Zone and Crack Location

The author was aware, from the previously mentioned experiments, of the fact that the cracks were not deep. It has been shown in Fig. 10 that the depth of the crack approximated the depth of the heat-affected zone. The higher ductility properties of the base material apparently did not permit the crack to propagate in the depth direction. To further check the extent of the heat-affected zone, the ballistic plate mentioned earlier in this report was sectioned so as to obtain samples from the cross section of the oxygen-cut edge. One sample was obtained utilizing a 350° F preheat while another sample had no preheat prior to the oxygen cutting operation. The cross-sectional samples were polished and a Tukon hardness survey made. The results of this survey are noted on Fig. 13. The dark etching edge, which has been reported by R. M. Komarnitski,† was apparent. This edge has been reported as being composed of grains outlined with brittle molybdenum carbide. The first cut edge of the no preheat sample was harder than that of the 350° F preheat sample. A similar relationship existed for the second cut surfaces. The depth of the heat-affected zone was slightly greater for the first cut of the 350° F preheat sample than the first cut of the room temperature sample. It can be noted on Fig. 13 that the total heat-affected zone closely approximated $^1/_{16}$ in. for all four cuts. At the point of gas impingement on the work this depth is somewhat greater. In addition, the 45-deg angle relationship of the two bevel faces lengthens the heat-affected zone so it is approximately $^1/_8$ in. This correlates with the spacing between the apex and crack extremity on the first cut surface. The dark etching edge was deeper in the case of the 350° F preheat cuts than it was for the room temperature bevel cuts. Whether this is significant or not is not known. The author also noted and as can be

* The yield point and ultimate strength are practically the same for an untempered martensitic steel.

† Chief Metallurgist, Rockwell Spring and Axle Co. This unpublished work had been reported at a meeting of the Ordnance Advisory Committee on the Welding of Armor.

seen on Fig. 13 that two shades of the hardened zone are present. Undoubtedly, this shading is the gradual transition to higher transformation products because of the lower rate of quench as we move away from the oxygen cutting edge (and A1–A3 zone). The ductility properties of the heat-affected zone are considerably less than the base material. This is based on the well-known work of Janitzky and Baeyertz[1] relating the properties of steels as a function of hardness. They have indicated an increase in the static elongation properties approximately threefold when the Brinell hardness changes from 500 to 200. Apparently, from Fig. 10, the stress condition and the material properties are such that the crack does not penetrate any deeper than the brittle martensitic zone.

The Solution

The author felt that the natural course to approach in order to eliminate this cracking problem would involve a double-edge objective. First, we would attempt to reduce the tensile stress condition on the first cut edge introduced by the second cutting operation. Second, we would attempt to improve the ductility properties of the first oxygen-cut edge so that it would be in a more favorable state to accommodate the stress condition. It was reasoned that the application of heat, as had been suggested by others in the past to reduce various other cracking conditions, would accomplish this. The author felt that the application of heat would reduce transverse cracking for the following reasons:

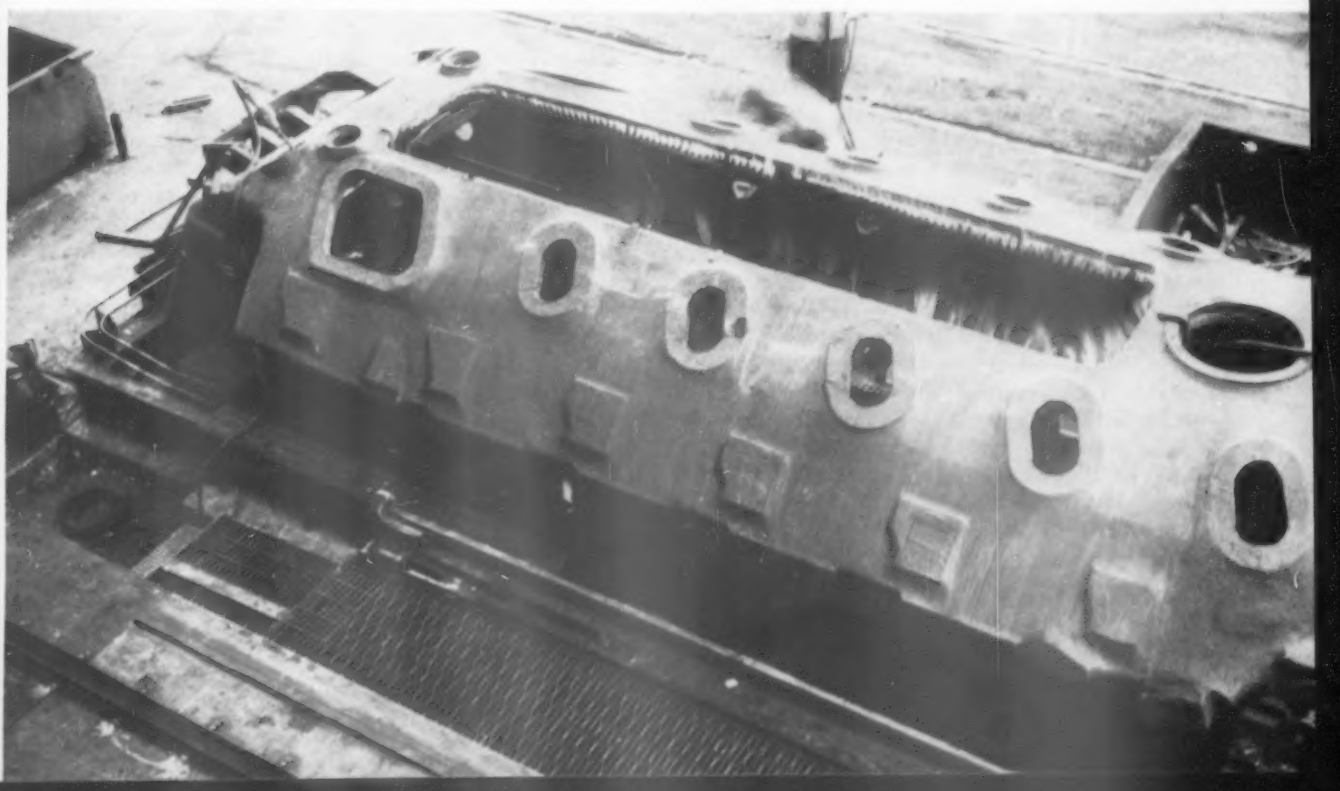
1. By preheating the sample the temperature gradient in the cutting operation, which reflects the difference in temperature ranging from the cutting temperature to the base material temperature, will be reduced. This gradient, it can be reasoned, will be less when the base material is 350° F than when the heat flow is absorbed into a room temperature heat sink (see Fig. 11). The dilatometric expansion gradient would be reduced using the preheat.

2. The ductility properties, under dynamic stress conditions, will be improved at higher temperatures as compared with room temperature conditions. By this statement it is meant that, under a dynamic test such as the Charpy impact comparison, it is more likely that the material will be tougher at 350° F than at room temperature.

3. The hardness of the first cut surface will be somewhat reduced by the lowering of the oxygen cutting temperature gradient. The corresponding lower rate of quench will produce a softer, tougher microstructure for any given preheat condition.

Reason 2 listed above was verified for the Mn-Ni-Cr-Mo analysis by using a simple experiment. Fourteen V notch Charpy specimens were machined from as-quenched armor. The results of breaking two specimens at each testing temperature have been plotted on Fig. 15. On the portion marked "heating" the specimens were raised to the testing temperature and broken after a one-half hour hold time. It can be seen that the dynamic toughness property improved as the testing temperature was increased. The as-quenched Rockwell "C" is 52 up to 212° F. At 350° F the tempering effects soften the samples to 50 R_c (hardness determined at room temperature). Specimens were originally raised to 350° F and then were allowed to cool to room temperature. They were broken at various temperatures and the results are shown on the curve marked "cooling." Increasing the breaking temperature from room

Fig. 14 Arrangement used to preheat hulls prior to scarfing floor plate section



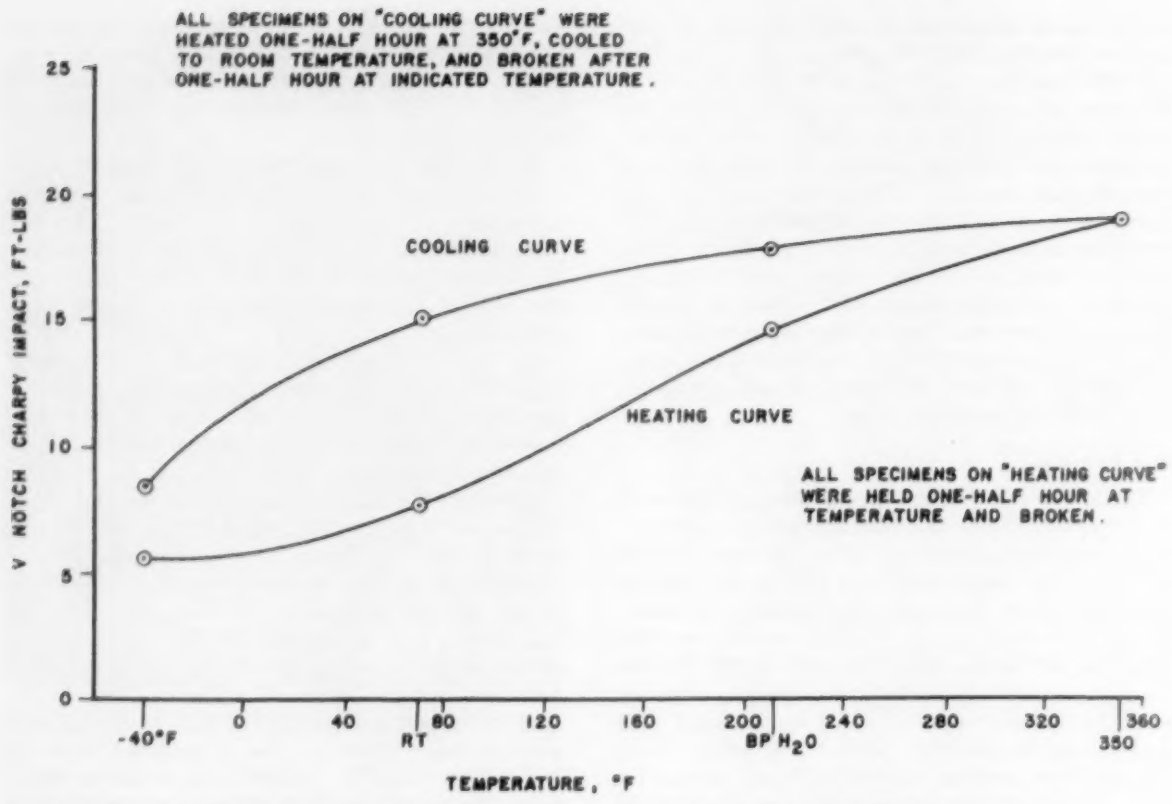


Fig. 15 Effect on V notch Charpy toughness of fully quenched armor tested at various temperatures

temperature to 350° F raised the toughness from 7.5 to 18.7 ft-lb. Part of the toughness increase is due to the tempering effect of the 350° F treatment. This can be concluded because when the 350° F samples are cooled to room temperature the breaking values are 15.0 ft-lb. Therefore, it can be seen that the 350° F preheat will toughen the steel by softening it as well as providing a more favorable ductility condition.

Initially, our attempts to preheat the edge were confined to four methods which gave only partially satisfactory results. First, by employing a lead preheat torch on the first oxygen cut surface during the second bevel-cutting operation we were able to enjoy second order improvements. Second, by employing a postheat operation following the first cut, very slight improvement was realized. Third, we were able, by utilizing a scrap cut, to create sufficient heat input which slightly reduced the amount of transverse cracking in the subsequent beveling operation. Fourth, we attempted, by reducing our cutting oxygen pressure, to minimize our cracking problems. We had been informed that this had helped others reduce cracking problems in oxygen cutting. No relief of significant magnitude was obtained with this method.

A fifth method, which employed a ring of flame for preheating the scarfing stock in the floor plate section of the hull, was finally devised, with the help of the East Chicago Hull Fabrication Shop, and this proved to be the solution to our problem. The combustible fuel is natural gas which is piped in from Texas and has a heat content of 1024 Btu per cu ft. Figure 14 shows the ring of flame which we employed to locally preheat each hull to 350° F for the beveling operation.

Transverse cracking has been reduced to an insignificant level. Each cut edge is still dye-checked 100% and it has been found that by utilizing this 350° F heating arrangement the savings in dollars and cents have been considerable. Approximately 6 hr of crack removal time and repair welding time per hull has been eliminated. In addition, this new method has produced a better product with the assurance that subsequent field operations of vehicles welded using this preheating arrangement will be less prone to produce weld joint deficiencies.

Acknowledgment

The author wishes to express his sincere appreciation to H. C. Weber, Welding Superintendent of the Hull Fabrication Shop, Continental Foundry & Machine Division, Blaw-Knox Co., who assisted considerably in the solution to this problem and to the Ordnance Tank-Automotive Command, Detroit Arsenal, for supplying the lead illustration of this article.

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STATUS OF EFFORTS TO DEVELOP NONMANUAL PIPE-LINE WELDING METHODS

Pipe-line industry searches for a fast welding process applied by lightweight, compact, automatic equipment which also involves low-cost operation

BY PAUL S. REED

Pipe-line welders work in muddy ground and under other terrain and climatic difficulties. Helpers are holding shields to protect welders running root bead in pipe gang

Introduction

If pipe-line welding by manual electric-arc welding is satisfactory, why is an effort being made to seek a nonmanual process?

Manual electric-arc welding has proved to be efficient and flexible. However, it is the bottleneck in pipe-line construction progress. All of the other operations in the building of pipe lines can move ahead at a faster daily rate than those for adding a joint of pipe to the line already welded. Furthermore, delays resulting from handling a large welding crew in a pipe-line construction spread inevitably reduce footage output. (The spread is the contractor's unit of organization and includes all crews or gangs working together as a team.)

Therefore, it would be advantageous to have a welding process which would not depend on manual dexterity. It should be applied under close control with compact equipment operated by personnel that could be readily trained. Such a process should be suitable for both joining two short joints to make a long joint (without rotation of the pipe) and for adding joints to the line already welded. Such a process could increase the contractor's profit by enabling his spread to produce greater footage.

Faster progress for the spread as a whole would be more important than reduction in the cost per weld. For welding costs alone amount to only 15 to 22% of the contractor's total cost.

By first discussing the functions of welding gangs in a pipe-line spread, the way will be prepared for later describing the features of several nonmanual processes proposed for the solution of the problem.

Special attention is now being given to developing two of these processes for pipe-line welding: (1) carbon-dioxide-gas-shielded metal arc with consumable electrode, and (2) thermit. Efforts toward an induction pressure-welding process are being deferred until the possibilities of carbon-dioxide gas welding are further explored.

This discussion deals with possibilities and limitations of processes studied in the pipe-line welding project of Esso Research and Engineering Co.

An outline of spread operations will assist in explaining why gas-pressure welding and submerged-arc welding were extensively tried and then largely dropped from pipe-line construction. This outline may also indicate construction conditions which would make it difficult to use flash welding for overland mobile pipe-line construction. However, flash welding might conceivably fit yard operations in certain situations.

Contractors build nearly all of the petroleum and

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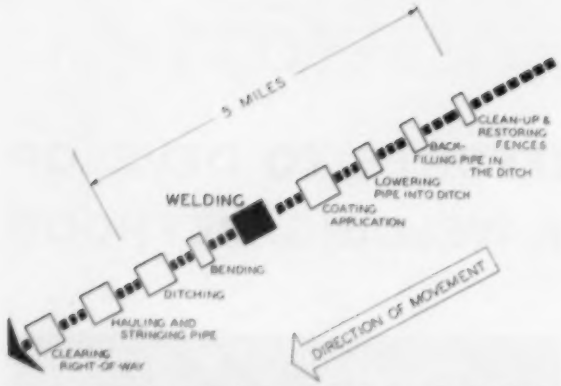

Fig. 1 Size of rectangles on spread diagrams indicates relative cost of operating each gang in a pipe-line construction spread. All gangs can now progress faster than the welding gang

natural gas pipe lines (4- to 36-in. diam) laid in the United States and Canada. These are laid at a rate of 16,000 to 18,000 miles per year. "Big-inch" construction (20–36 in.) is predominant.

Current Construction Practices

Spread Operation

A contractor's spread includes all gangs working together as a unit for the entire range of operations extending from clearing of the right-of-way through ditching, welding, coating, lowering the pipe into the ditch, backfilling and clean-up (see Fig. 1).

Since the application of nonmanual welding would be most important in laying pipe of large diameter, a "big-inch" spread (20–36 in.) will be described. Such a spread has equipment costing $750,000 to more than $1,000,000 and employs 200 to 300 men. Daily cost runs $15,000 and upwards. Contractor's gross price for laying 30-in. pipe—for example, run from $2.50 to $9.00 per ft ($4.25 per ft average) depending on terrain and other conditions. Good daily output for laying 30 in. is regarded as 5000 to 6000 ft with standard length joints (30 to 40 ft). When long or double joints (60 to 80 ft) are used, output increases to 8000 to 10000 ft and sometimes more per day.

A spread progressing at the rate of a mile per 10-hour day makes 132 welds (4.5 min per weld). When a spread is making good progress it will be observed on the job that joints are frequently added to the line with fair regularity in a little over 2 min.

Double Jointing

Therefore the long joints (60–80 ft) facilitate greater footage with larger profits where terrain and other conditions are favorable. They take little more time to line up than the short joints (30–60 ft).

However, percentagewise, only a minor amount of long joints (60–80 ft) are now used. A suitable nonmanual welding process (not requiring rotation of the pipe) would make it easier to procure the long joints by welding on the right-of-way ahead of the main welding operations.

The making of these long joints, called double jointing, may be done at any one of three points—pipe mill, railhead yard, and on the right-of-way. Such double jointing consists of making two 30-ft joints into a 60-ft joint, or two 40-ft joints into an 80-ft joint. Most of the mill and yard double jointing has been done by manual electric-arc welding; a much smaller amount has been done by submerged-arc welding.

Double jointing at temporary pipe yards at a distance from the right-of-way is often restricted by legal and highway requirements which prevent trucking of long joints to the right-of-way. Therefore it would be desirable to have a convenient process for double jointing on the right-of-way, ahead of the point where each joint would be added to the line. In a few cases such double jointing by manual electric-arc welding is occasionally done on the right-of-way in flat terrain. There have been a few experiments with submerged-arc welding for double jointing on the right-of-way. But the need for leveling the pipe and rotating it has brought complications that have been discouraging.

Cost Percentages

The relation of welding to other pipe-line construction costs can be indicated percentagewise for large-diameter pipe operations, as follows:

Pipe-Line Construction Operation Costs

Type of operation	%
Clearing right-of-way	13
Hauling and stringing pipe	15
Ditching	15
Welding	15
Coating application	15
Bending and lowering into the ditch	14
Backfilling pipe in the ditch	7
Clean-up and restoring fences	6
	100

Thus it is clear that a process which would slow down pipe footage output by even a small amount would not be advantageous even though it might decrease the actual cost per weld. On the other hand, a process offering no reduction in welding cost could be profitable if it were suitable for double jointing. Greater profit would be expected from the resulting larger daily pipe footage.

Stovepiping

How does the contractor make the fast progress of adding a joint every $2^1/_2$ to $4^1/_2$ min.?

The contractor uses an assembly-line method of welding known as "stovepiping" that is peculiar to pipe lining. (The name itself is something of a misnomer for it has nothing to do with stove pipes.) It consists of adding one joint at a time with root and reinforcing beads run by the crew known as the pipe gang which is followed by a firing-line gang that completes the weld. Here is how the pipe gang works:

It lines up the joint being added and runs the root bead, called the stringer bead—and also the reinforcing

Fig. 2 Three stringer-bead welders simultaneously running a root bead on 30-in. diam pipe in Mississippi

bead, called the hotpass. Output of the pipe gang determines the contractor's profits.

Ahead of where the pipe gang works, the right-of-way has already been cleared and graded for movement of construction vehicles. The ditch has been dug. Pipe has been strung along the ground in 30 to 40, sometimes 50 ft lengths. The joint is usually designed with a 30-deg bevel, but some companies specify 37 1/2-deg bevel; the land is 1/16 in.

Pipe Gang

Just before welding, the pipe ends are cleaned by a power-driven buffing machine. The joint to be added to the line is placed over the internal line-up clamp by a boom tractor. Spacing is 1/16 in. Line-up clamps are mostly of a mechanical type operated by a hand-manipulated crank at the open end of the pipe. Some pneumatic clamps have been successfully used recently. After the internal line-up clamp has been expanded, the "high-lows" are pounded out by two men with sledge hammers—taking about 1/2 to sometimes 1 min. On pipe of 12 in. and less in diameter external line-up clamps are used.

The root bead, usually run with a 5/32-in. AWS-E6010 electrode, is applied by two to four stringer-bead welders welding downhill. Three stringer-bead welders on 30-in. pipe are fairly common: one welder squats on top; the other two work at staggered positions on the sides (see Fig. 2). The root bead on 30-in. pipe is completed in 40 sec to a minute or a little more.

The 300-amp. generators of the stringer-bead welders are carried on one truck. Those of the hot-pass welders on another truck (see Fig. 3).

Wood skids are placed under the joint or length of pipe being added to the line. Shortly before or on

Fig. 3 Joint being lined up by pipe gang. Rod for manipulating internal line-up clamp protrudes from pipe. Welding machines of stringer bead and hot-pass welders are on trucks in the rear

Fig. 4 Special barge for laying gas pipe line offshore this year near the Louisiana coast. Three double-jointing stations (at left) prepare long joints for launching line (at right). Position welds are made at all stations. The rollers do not rotate the pipe

completion of the root bead, the line-up clamp is released and started toward the end of the pipe to receive the next joint.

Immediately behind the stringer-bead welders, are the hot-pass welders running reinforcing beads with $^5/_{32}$-in. AWS-E7010 electrode to strengthen the root bead. Four hot-pass welders are being used in the pipe gang for 30-in. pipe construction on big projects.

Slag is removed by helpers using hand and/or power tools.

The whole pipe gang has 25 to 30 men including foreman, welders, spacer, tractor drivers, helpers, and other laborers.

Firing Line

Behind the pipe gang follows the firing line where each weld is completed by running the filler bead ($^3/_{16}$-in. AWES-7010 electrode) and the finish or cap bead ($^3/_{16}$-in. AWS-E6010 electrode). All welding is downhill in pipe-line construction.

Altogether there may be 12 to 16 welders in the firing line. Trailers on which 200- to 250-amp generators are mounted are usually pulled ahead by tow tractors.

Welding is conducted on sections of pipe of 2000 ft and less in length. In order that the welding operation may be separated from the vibration of pipe occurring in the cleaning and coating, these latter operations are not performed on the same section of pipe where welding is done.

Such disconnected sections and also those at road and stream crossings are welded together for tie-in by one or more crews of utility welders after the pipe has been coated and lowered into the ditch.

Each welder in a pipe-line construction spread customarily has a helper.

The whole "stovepipe" spread operation from ditching to backfilling the pipe in the ditch extends from 3 to 5 miles on most spreads. The stovepiping is also the basic method for offshore barge pipe laying (see Fig. 4).

Roll Welding Discontinued

Before 1944, when roll welding of long sections of several joints to 200 ft or more was fairly common, a spread often stretched out to 10 miles. But extensive roll welding is now obsolete on pipe lines.

The discovery of substantial economies resulting from closer supervision of the shorter stovepipe spread led to discarding the longer more-loosely supervised roll-welding type of spread. Likewise, intangible economies resulting from closer supervision would increase contractor's profits if a compact nonmanual process could be used to reduce the number of welding units on the right-of-way. Such nonmanual units would advantageously shorten the line of construction operations.

Radiographic inspection is conducted by crews traveling with each spread. Customarily, at least 10% of the welds are radiographed in overland construction. For submerged lines 100% are radiographed.

Physical tests of coupons are tensile, bend and nick break.

Nonmanual Processes Considered

Nonmanual welding processes may be coming over the horizon into pipe lining. As yet, none of them is now ready to go out on a pipe-line right-of-way, and it does not look as though any will be ready for testing on a pipe-line job for at least a year.

Manual electric-arc welding now thoroughly established in pipe lining is a highly developed and versatile technique, a tough competitor for any new welding process to go up against.

CO_2 Gas Welding

The carbon-dioxide-gas-shielded metal-arc process with consumable electrode is being given top consideration for nonmanual welding because it seems to offer low investment, small power requirements and easy application. It is a fast, simple, low-cost method.

Because of the high rate of depositing metal and the low unit price of carbon dioxide, this process has brought low welding cost in the fabrication of mild steel. Welds of excellent quality are produced with visible arc and without flux, thus eliminating the need for slag removal. The high currents and deep penetrating arcs of carbon-dioxide welding require an automatic travel mechanism for getting the best results.[1-3]

Main features were demonstrated in a similar process using inert gas in the welding of aluminum pipe near Corpus Christi in 1954 (see Fig. 5). The problem of welding at the bottom of the pipe between the 5

o'clock and 7 o'clock positions has not yet been satisfactorily solved. But prospects are encouraging.

The entire welding apparatus rotates on the pipe. Operation can be by push button. The operator needs no manual skill and he can learn how to run the machine in a few hours. If he is an experienced welder, he will naturally be a better operator. Furthermore, he can watch the weld being made and can correct for faulty operations. This is advantageous together with the fact that carbon-dioxide gas welding is another form of the now familiar electric-arc welding method. Therefore, it can be inspected by the same radiographic techniques now being used on pipe lines.

The welding power supply required for this process is a standard 400-amp d-c welding motor-generator set of the same type now used for pipe-line construction.

With the carbon-dioxide gas process, an 8-in. diam pipe with $^1/_4$-to $^3/_8$-in. wall can be welded in a minute with one bead applied by a single arc. This includes removing the unit and going to the next weld.

For larger diameters, it is expected that more arcs could be added to keep welding time down to about a minute. Cost of materials for an 8-in. weld would be one cent for carbon dioxide and five to six cents for welding wire. Carbon dioxide could come in either liquid or cake form. Total cost of welding for an 8-in. weld would be six to seven cents per weld for materials plus cost of labor, fuel and equipment.

Laboratory tests made on welds produced by this method gave the following results:

Guided-root and face-bend tests were made through 180 deg without failure. In tensile tests (yield strength 44,700 psi and tensile strength 69,600 psi) the specimens broke outside the weld. Nick-break tests showed sound weld metal.

Macro examination revealed incomplete root penetration and a trace of porosity. Weld reinforcement was nonuniform in depth, some areas being under flush and there was a general lack of penetration through the root of the joint. The mechanical properties of the weld, however, were satisfactory. And it is believed that pipe welds can be developed to a point where satisfactory carbon-dioxide gas process welds can be consistently made.

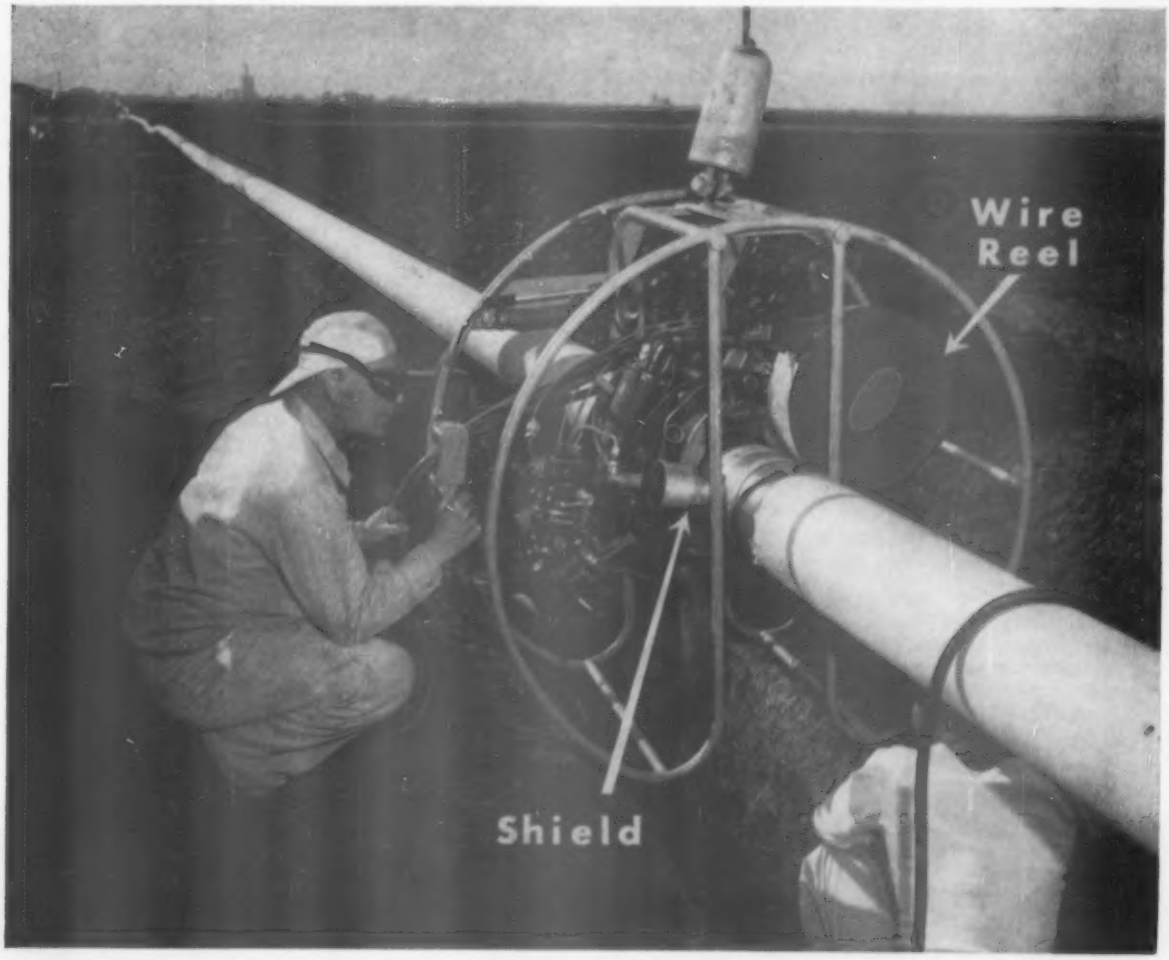

Fig. 5 Aluminum pipe being welded near Corpus Christi, Tex., by inert-gas-shielded metal arc with consumable electrode. This machine was later used in a laboratory for development of the carbon-dioxide gas process for welding steel pipe

Thermit

Going in another direction, it might be possible to develop a thermit process for pipe-line welding. Thermit is a simple method for making welds on small diameter pipe with unskilled labor at certain times and places where electric-arc welding would not be available. Research might even develop a method which would be good for making the largest diameter welds. Even though thermit might not be cheaper than electric welding it may be useful for some emergency situations.

If improvements can be made in molds and practices for more efficient application of thermit and for the reduction of the size of the upset, the process would be more usable for pipe welding.

Thermit may be a handy process to use for gathering line construction—particularly in foreign operations when electric-arc welding may not be available. There may be cases in pipe-line construction when welders may not be on the job for completing a last short stretch of a fairly big job. A simple welding method not requiring manual skill might be desirable.

On some types of jobs thermit may be cheaper. But even though it may be discovered that it costs more, there would be advantages in having an alternative welding technique—another method—when electric-arc welding is not available.

Induction Welding

Until the carbon-dioxide gas process for welding steel pipe became promising, induction pressure welding was the most attractive possibility in recent years for nonmanual welding of pipe lines. If the carbon-dioxide process does not come up to expectations, interest may be revived in developing an induction pressure-welding process.

For a fresh attempt to develop a solid-phase pressure-welding method for pipe lines, it now seems better to use induction heating than gas heating (see Fig. 6). Induction welding of pipe is still in the early stages of development. Heat applied by an induction coil would not vary like that of a gas flame affected by irregularities in burners and supply of gas, also from the effect of the wind and from errors in judgment of the operators.

On the other hand, the gas flame has the advantage of protecting the weld against oxidation. Protection against oxidation is a vital problem of the induction method.

For uniform heating there should be some rotation of the induction coil.

Induction welding is done by high pressures (7000 to 10,000 psi) and lower-than-fusion temperatures (1800 to 1900° F). Induction allows the heat to be concentrated entirely at the butt joint, thus eliminating deformation of adjacent sections or change of metallurgical properties. The induction coil remains cool while heat is induced in the pipe.

For welding 30-in. pipe, the largest part of the induction welding unit would be the 400-hp mobile power plant, weighing 14 to 18 tons. A complete pressure weld would be made in 30 sec. The entire operation of line-up and welding would be about 2 to 3 min. Operating personnel would be an electrician and one or two helpers and a tractor driver.

Power would be 60 cycles, 220–240 volts, 3 phase. Frequency of induction welding would be between 1000 and 3000 cycles.

Induction welding costs have been estimated between $14 and $16 per weld for 30-in. diam pipe with $^3/_8$-in. wall. These costs include labor, fuel and amortization of a $150,000 unit. The relation of amortization to manual arc welding costs is indicated in Fig. 7.

A special external hydraulic clamp would be desirable for insuring close line-up.

If induction welding were used on pipe lines, the advantages of this process would increase progressively for the larger diameters as it would with most nonmanual processes. For no more time would be taken in making a large-diameter than a small-diameter weld.

But as mentioned earlier, effort on induction welding for pipe lines was suspended because of the promising possibilities of the carbon-dioxide gas process.

Gas pressure welding demonstrated what could be accomplished by making pipe-line welds with heat and pressure. From 1941 through 1946 more than 1000 miles of pipe were gas pressure welded. Difficulties experienced in most cases could be traced to irregularities due to small details, which might have been corrected by a development program. Much policing was

Fig. 6 Gas pressure welding on oil line in Texas. While the gas pressure technique has been discontinued, it accomplished results which now encourage development of pressure welding with other sources of heat

needed to insure that pipe ends were properly cleaned before welding.

In spite of much serious trouble on some projects, gas pressure welding was satisfactory in laying many miles of pipe that continue to give good service.

Submerged Arc

Since automatic and semiautomatic submerged-arc welding requires rotation of the pipe, it has been applied almost entirely at yards. At such yards, root beads are customarily run by manual electric-arc welding and completed with automatic welding.

Following its biggest use in the 1949–1950 period, submerged-arc welding has declined so that now only one or two contractors have been operating yards with this process in the past year. The only completely automatic operations for running all beads by submerged arc were in 1949 and 1950 at the Ras el Mishaab yard in Saudi Arabia and later at a western pipe mill.

After several attempts to apply submerged-arc welding for mobile operations on the right-of-way, nothing has been reported for such methods in the last three years. The bulkiness of the equipment and the difficulty of rotating the pipe in a horizontal position have discouraged further efforts with this method on the right-of-way.

Portable yard equipment for double jointing pipe by use of manual electric arc for root beads and automatic submerged arc for the other two beads has been operating at only a few locations this year in the construction of natural gas pipe lines in the United States and Canada.

Flash Welding

Makers of flash welding units have warned against two features of flash welding they believe will be objectionable for pipe lining. One is the operation of removing the internal upset or "flash" consisting of flaky and abrasive extruded vanes. Broaching for internal flash removal should be done immediately after welding while the metal is still hot. Broaching would be awkward on the right-of-way but it could be done in a yard operation. The external flash needs to be removed by grinding to prepare for coating application.

Large power requirements and the need for rigidity of the flash-welding unit call for costly heavy equipment which would be cumbersome to move over a rough right-of-way. Furthermore, such a unit would be restricted to operating in a limited diameter range. A yard unit for flash welding $4^1/_2$- to $8^1/_2$-in. pipe would cost $150,000 to $170,000 for welding, broaching and pipe-handling equipment. In addition, electric power would have to be furnished for a 1200-kva maximum upset demand. A single-phase diesel generator for this service would cost about $130,000. So the total investment could amount to $280,000 to $300,000. The welding and power equipment would weigh a total of 280,000 lb.

The unit could be operated by two or three men with an output of 10 to 30 welds an hour in diameters of $4^1/_2$ to $8^1/_2$ in.

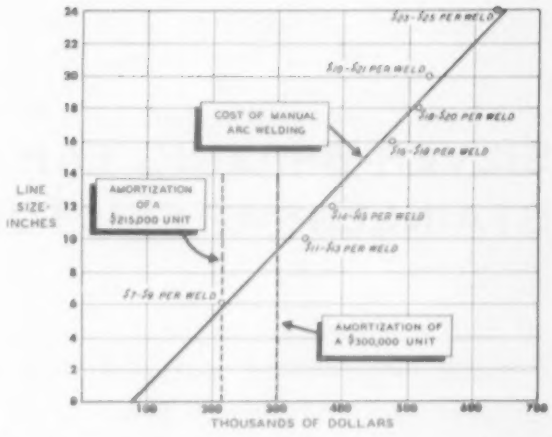

Fig. 7 Amortization of hypothetical high cost mechanized welding equipment to be paid out on a 200-mile job is compared with costs of welds by manual electric welding. The chart indicates roughly the investments which might be justified by mechanized welding units

A mobile flash unit has been proposed using a large storage battery to reduce power requirements but it has not yet been built.

Conclusion

In the search for a fast process applied by lightweight, compact, automatic equipment which would also promise low-cost operation, the carbon-dioxide gas process appears to be the most attractive possibility for pipe-line welding—provided that the quality of welding at the bottom of the pipe can be improved to meet requirements.

Thermit may be a useful alternative process for certain applications on small diameter pipe and for meeting emergencies.

Induction pressure welding is a possibility which might be later explored.

Increased spread output is more important than lower cost per weld. A new process would be of greatest advantage to pipe-line construction by contributing to the output of a spread—probably by facilitating double jointing on the right-of-way. Other advantages might come through reducing the space covered by welding operations, thus bringing economies resulting from closer supervision.

Acknowledgment

The author wishes to express his appreciation to the H. C. Price Co. for supplying the lead photo for this article.

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SILVER-BRAZING LAP JOINTS IN STAINLESS-STEEL TUBING

Properly made silver-brazed joint in stainless-steel tubing shown to be stronger than tubing if lap is made three times the thickness of the tubing

BY G. H. BOHN

Silver brazing stainless-steel tube into fitting for 3500 psi WP

SYNOPSIS. This paper presents experimental data and calculations to show that if the lap of a properly made silver-brazed joint in Type 300 Series stainless tubing with commercial mill tolerances is made three times the thickness of the tubing, the joint will be stronger than the tubing with internal pressure, tension stresses due to thermal expansion and dead load, or a combination of the two.

Introduction

It is a recognized fact that the strength of a silver-brazed lap joint in stainless steel is dependent on the clearance between the two members being joined.[1, 2]

The normal mill tolerance on stainless-steel pipe and tubing makes it impractical, from a production viewpoint, to machine couplings and other fittings to produce the small clearances necessary for maximum strength silver-brazed lap joints.

Since clearance influences the strength of the joint, it is convenient to have a rule of thumb for determining the lap required when silver brazing a pipe or tube into a coupling or into the shell of a pressure vessel. To be of value, the rule of thumb must take care of normal clearances which can be expected under fabricating shop conditions. The following discussion will show that such a rule, which is practical and yet safe, can be established.

This paper only evaluates the 300 Series of stainless steel and not the 400 Series. Whenever the term "tubing" is used in this paper, it is understood to also include pipe.

Properties of a Satisfactory Lap Joint

Service piping is normally subjected to thermal stresses in addition to pressure stresses. The calculation of thermal stresses is complex and time consuming; however, the determination of its effect on the required length of lap will be unnecessary if the properties of a satisfactory joint are defined as follows:

"The requisites of a satisfactory lap joint are such that (1) the joint will not fail when the tubing ruptures longitudinally due to pressure, and (2) the joint will not fail when the tubing ruptures crosswise due to direct tension stresses."

This, therefore, means that the joint must incorporate a factor of safety slightly higher than that used in the design of the tubing.

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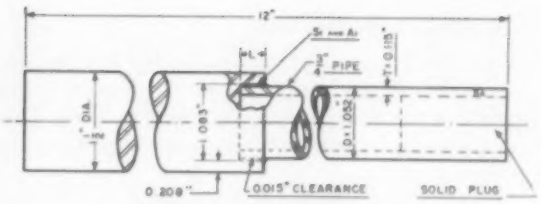


A_1 = SHEAR AREA, SQ IN. (SURFACE AREA OF OVERLAP)

A_2 = CROSS SECTIONAL METAL AREA OF PIPE, SQ IN.

L = LENGTH OF LAP, IN.

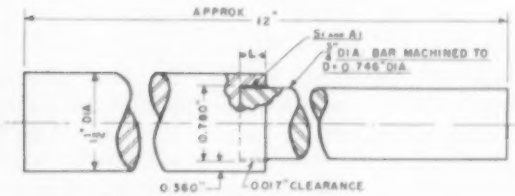
S_1 = ULTIMATE SHEAR STRENGTH OF BRAZING ALLOY, PSI

S_2 = ULTIMATE TENSILE STRENGTH OF PIPE, PSI

T = WALL THICKNESS, IN.

D = OUTSIDE DIAMETER WHEN T IS 10 PERCENT OR LESS THAN O.D., IF GREATER THAN 10 PER CENT, USE MEAN DIAMETER OF TUBE

Fig. 1 Test specimen—test A



A_1 = SHEAR AREA, SQ IN. (SURFACE AREA OF OVERLAP)

L = LENGTH OF LAP, IN.

S_1 = ULTIMATE SHEAR STRENGTH OF BRAZING ALLOY, PSI

D = OUTSIDE DIAMETER WHEN T IS 10 PERCENT OR LESS THAN O.D., IF GREATER THAN 10 PERCENT, USE MEAN DIAMETER OF TUBE

Fig. 2 Test specimen—test B

Tests

Two different tests were made to determine the ultimate shear strength, at room temperature, of ASTM-B260, BAg-3 brazing alloy in a stainless steel to stainless-steel lap joint. The specified analysis of this brazing alloy is:

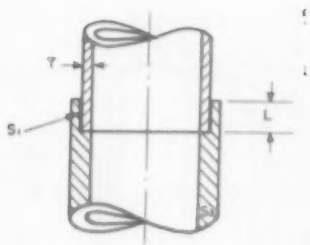
Silver, %	49.0–51.0
Copper, %	14.5–15.5
Zinc, %	13.5–17.5
Cadmium, %	15.0–17.0
Nickel, %	2.5– 3.5

The nickel content[2] plus the low zinc content makes the brazing alloy particularly suitable for stainless-steel brazing.

This brazing alloy starts to liquefy at 1195° F and is fully liquid at 1270° F. The plastic range is therefore 1270–1195 or 75° F, thus making it particularly suitable for lap joints. The reason for this is explained later in the paper.

Test A—Determination of Ultimate Strength of Pipe and Silver Solder

A $^3/_4$-in. Schedule 40S, Type 304 stainless-steel seamless pipe was silver brazed into a coupling made from $1^1/_2$-in. diam stainless-steel round. The bore of the coupling was made 0.031 in. larger than the actual outside diameter of the pipe to give approximately 0.015 in. clearance on a side. The assembly was then subjected to a gradually increasing tensile load in a tensile machine until failure occurred in either the tubing or the joint. Different laps were tried so that failure would occur in the tubing in one case and the joint in the other case, thus establishing both the strength of the tubing and the shear strength of the silver-brazed joint.



L = LENGTH OF LAP, IN.

S_1 = ULTIMATE SHEAR STRENGTH OF BRAZING ALLOY, PSI.

S_2 = ULTIMATE TENSILE STRENGTH OF PIPE, PSI.

T = WALL THICKNESS, IN.

Fig. 3 Typical silver-brazed tube lap joint

Figure 1 is a sketch of the test assembly.

The results of Test A were as follows:

	Silver-brazed lap (0.0155 in. thick)		
Length of lap, in.	0.156	0.285	0.375
Ratio, lap/wall thickness,	1.355	2.48	3.27
Location of failure	Joint	Pipe	Pipe
Breaking load, lb	24,650	30,000	30,300
Tensile strength of pipe, psi	...	87,500	88,500
Ultimate shear strength of BAg-3, psi	48,000	...	...

Test B—Determination of Ultimate Strength of Silver Solder

A $^3/_4$-in. diam Type 304 stainless-steel bar was silver brazed into a coupling made from $1^1/_2$-in. diam bar. A joint clearance of 0.017 in. on a side was provided. This assembly was tested in a manner similar to that described for Test A. Figure 2 is a sketch of the test assembly.

The results of Test B were as follows:

	Silver-brazed lap (0.017 in. thick)	
Length of lap, in.	0.250	0.344
Ratio, lap/wall thickness,	0.693	0.955
Location of failure	Joint	Joint
Breaking load, lb	24,190	31,415
Ultimate shear strength of BAg-3, psi	41,300	39,100

Development of Rule of Thumb for Lap

The following is a development of a rule of thumb for the silver-brazed lap for any metal or combination of metals so as to satisfy the requirements given under "Properties of a Satisfactory Joint." Figure 3 illustrates the lap joint.

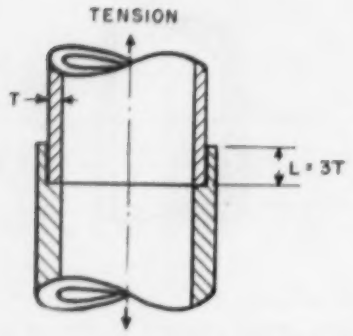


Fig. 4 Basis of design for silver-brazed tube lap joint

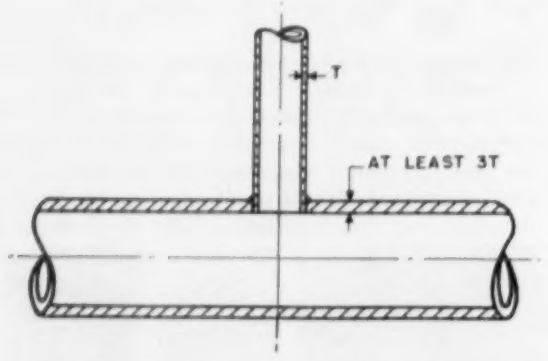


Fig. 5 Silver-brazed thin wall tubing in thick wall pipe

Case 1—Internal Pressure Governs

A formula has been developed to determine the required length of lap when internal pressure governs. In this case, if the lap is made long enough, the tubing will rupture longitudinally when such an assembly is tested to rupture by internal pressure. The formula to determine the lap is $L = S_2T/2S_1$.

Case 2—Direct Tension Governs

A second formula has been developed to determine the length of lap when there is tension in the tubing due to dead load or expansion stresses. In this case, if the lap is made long enough, the tubing will rupture crosswise when the assembly is tested to rupture in the tensile machine. The formula to determine the lap is $L = S_2T/S_1$. This is the formula that applies for Tests A and B.

Case 3—Combined Internal Pressure and Tension

Failure can occur due to the combination of pressure and direct tension loads and the higher the stress due to pressure, the less the permissible direct tension load. In this case the direct tension stress determines failure.

The formula is $L = S_2T/S_1$.

From this discussion, it is evident that the formula for Case 2 or Case 3 governs because the required lap is twice as long as for Case 1. Therefore, all calculations for the lap joint will use the formula $L = S_2T/S_1$.

Stainless Steel to Stainless Steel

Using the lowest shear strength of the brazing alloy (S_1) of 39,100 psi and the highest utimate tensile strength of the pipe (S_2) of 88,500 psi from Tests A and B in the basic formula, the minimum required lap becomes:

$$L = \frac{88{,}500 \times T}{39{,}100} = 2.26T$$

As such, however, failure could occur in either the joint or tubing but the constant 2.26 does set a lower limit.

All ASTM specifications give 75,000[4] psi as the minimum ultimate tensile strength for the Series 300 (austenitic) stainless-steel pipe and tubing. Also 25,000[5] psi is an arbitrary minimum ultimate shear value which can be expected from all silver-brazing alloys containing appreciable amounts of silver. Using these values in the basic formula

$$L = \frac{75{,}000 \times T}{25{,}000} = 3T$$

Experience has shown that the minimum value of 25,000 psi for S_1 is conservative; therefore, using $L = 3T$ failure should always occur in the tube. This is shown by Fig. 4.

A fundamental rule of thumb may, therefore, be written as follows:

A lap of 3T, where T is the thinner of the two actual thicknesses being joined, is sufficient in the case of stainless steel silver brazed to stainless steel to insure that the joint will not fail when the tubing is burst under pressure or is tested to destruction under a direct tensile load.

That this is true, has been proved by thousands of joints that have been made using the BAg-3 brazing alloy for pressures of full vacuum to 3500 psi and temperatures from liquid nitrogen (−300° F) to 300° F. These joints were not used for corrosive liquids or vapors. The permissible use of silver-brazed joints in stainless steel, which causes the formation of carbide precipitation in the nonstabilized stainless steels such as types 303, 304 and 316, would have to be determined by suitable tests. The same would apply if the joints were butt or lap welded.

The author recommends a $^1/_{32}$-in., 45-deg bevel on the female joint when torch brazing is used—this acts as a starter and prevents "spilling" of the expensive silver alloy over the outside of the parts.

This same rule of thumb can be used for thin wall connections in headers or piping such as is shown by Fig. 5.

Such a construction is difficult to weld because of the joining of the thin to thick wall tubes. Silver brazing is ideal.

A good practical rule to use on tubing having a wall thickness of less than $^1/_{16}$ in. is a minimum lap of $^3/_{16}$ in.

It was stated under "Tests" that the plastic range of 75° F of the BAg-3 brazing alloy was particularly suitable for lap joints. This will now be explained.

Most persons are familiar with the common 50% tin – 50% lead solder used for soft soldering copper joints. This soft solder starts to liquefy at 360° F and is full

liquid at 420° F, thus having a plastic range of 60° F. A truly eutectic soft or silver solder has no plastic range and so solidifies almost instantly when cooled. Difficulty is therefore encountered when attempting to run a eutectic or low-plastic-range soft or silver solder into a lap joint. Experience has shown that the 50–50 soft solder with its 60° F plastic range is ideal for lap joints. A solder with even a higher plastic range such as BAg-3 silver solder is therefore ideal for lap joints.

For furnace brazing, an eutectic or low-plastic-range silver solder is best because it is desirable to melt and solidify the silver solder within a short temperature range. The rule-of-thumb of a lap of $3T$ also applies to furnace-brazed joints.

According to the 1952 ASME Unfired Pressure Vessel Code, the strength of several 300 Series stainless steels decreases above 100° F; however, there is no appreciable decrease in the strength of a silver-brazed joint up to approximately 300° F; whereas, above 300° F, there is a very rapid decrease in the strength of the joint.[6] Therefore, it would appear that the fundamental formula $L = 3T$ is safe to 300° F maximum.

Stainless Steel to Copper and Copper Alloy

The fundamental rule of thumb for copper to copper and copper-to-copper alloy joints is $L = 2t$.[5] When silver brazing stainless-steel tubing in copper or copper-alloy fittings, the rule of thumb is still $L = 3T$ in order to make the joint stronger than the stainless tubing. The wall thickness of the copper or copper-alloy fitting would be thicker than a stainless-steel fitting in proportion to allowable design stresses. For instance, in ASME Unfired Pressure Vessels Code Table UNF-23, the allowable stress for copper-silicon is 12,000 psi from subzero to 150° F while in Table UHA-23, the allowable stress for Type 304 seamless stainless-steel tubing SA-213 or 312 is 18,750 psi from subzero to 100° F. For the same diameter, the wall thickness of the copper-silicon part would be 18,750/12,000 or 1.56 times as great as for stainless steel. Experience has shown that these two alloys are excellent for combination silver-brazed joints because the coefficients of expansion are the same within a percent or so. Silver brazing is preferred to welding for such combinations, particularly if the fittings are leaded yellow brass. Figure 6 is a typical design of a high-pressure silver-brazed construction that has proved successful. In this case, the forged elbow is made from leaded yellow brass which is relatively cheap as compared with stainless steel but it is not suitable for welding because of the lead content.

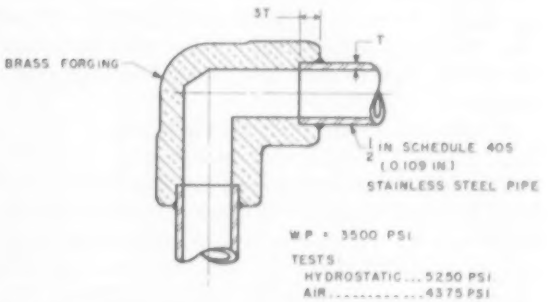


Fig. 6 Silver-brazed stainless-steel pipe in brass fitting

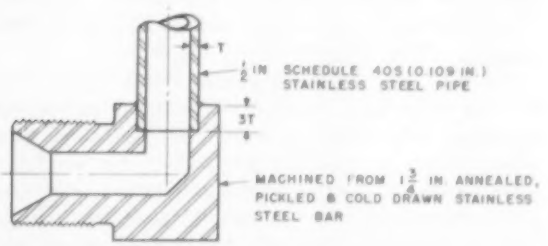

T
1/2 IN. SCHEDULE 40S (0.109 IN.) STAINLESS STEEL PIPE
3T
MACHINED FROM 1 3/4 IN. ANNEALED, PICKLED & COLD DRAWN STAINLESS STEEL BAR

Fig. 7 Silver-brazed stainless-steel pipe in stainless-steel fitting

Silver Brazing Cold-Worked Stainless Steel

Generally, stainless steel that has been cold worked by the mill or shop will often crack when silver brazed unless the cold-working strains are removed by annealing at 1950° F and air or water quenched. Whether the cold-worked stainless steel will crack depends on the amount of cold working. This usually can be determined by a hardness test and it may be necessary to use a superficial hardness tester. Hardness in the upper range of the Rockwell B scale or the lower range of the Rockwell C scale is the troublemaker. A few actual cases will be cited to illustrate the point.

One of the types of joints which are especially adaptable to silver brazing instead of welding is a stainless-steel pipe in the side of a stainless-steel fitting according to Fig. 7.

This construction, if welded, would cause puncturing of the pipe because the amperage necessary to melt the heavy fitting is too high for the thinner wall pipe. Silver brazing seemed to be the answer. However, when the first of 100 of such joints was tried, the fitting cracked. Every known procedure was tried and still the fitting cracked. An investigation showed that it is general practice for the mill to furnish hex bar up to approximately $2^1/_2$-in. sizes in annealed, pickled *and cold drawn*. A hardness test taken across the cross section of the material that cracked showed that the hardness at the edge for about $^1/_{16}$ in. was over Rockwell B95 and, in the center, Rockwell B80–85.

A piece several inches long was annealed at 1900° F furnace temperature in a small electric furnace for approximately two hours. This piece was cut in two and the hardness of the center cross section checked. The edge hardness was still over Rockwell B95. Another piece several inches long was annealed at 1950° F with a thermocouple on the work for 2 hr. This second piece was cut in two and the hardness of the center cross section checked. This time the hardness was uniformly Rockwell B80–86 with the center its original B80. About 100 fittings annealed with this procedure were machined, and then silver brazed. Not one cracked. The metallurgical answer as to why the

1950° F metal temperature reduced the hardness and the 1900°F furnace temperature did not, seems to be that the cold finishing was not of a high reduction nature and so a higher annealing temperature is required.

Later, an identical unannealed fitting was silver brazed the same way and it did not crack. A check on the hardness across the cross section showed that the hardness varied from B85 to B89 to the edge. The mill evidently did not cold work this hex as much. However, since the trouble occurred such a high percentage of the time, it was considered advisable to anneal all pieces before machining. No further cracking was experienced.

If a piece of sheet stainless steel is bent 90 deg on a small radius and the outer radius is silver brazed, the sheet will generally crack. Figure 8 is a photomicrograph of what happens when this is tried. It is to be noted that the silver alloy penetrated the stainless steel at the grain boundaries.

It is possible to produce the same effect when silver brazing into the outer surface of a small radius tube bend.

This leads to the suggestion to either avoid such constructions or to anneal the cold-worked bend or fitting before silver brazing. Another solution for fittings is to machine off at least $^1/_{16}$ in. to remove the cold-worked surface.

Determining Joint Diameter When Using Tubing

It is just as desirable in silver-brazed as it is in soft-soldered joints to have as close a tolerance as is possible. Unfortunately, the OD tolerance on stainless-steel tubing as compared with nonferrous tubing is much greater; so, the maximum possible clearance is much greater. It would be well to emphasize the fact

Fig. 8 Photomicrograph showing penetration of silver solder into stainless steel that occurs when the steel is in a highly stressed condition

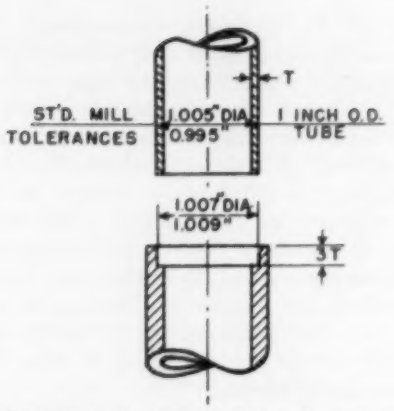


Fig. 9 Recommended design for 1-in. diam silver-brazed tube lap joint

that joint clearances of 0.015 in., such as used in the tests, are approaching a maximum and it would be better to limit the maximum joint clearance on a side to 0.010 in.[7]

The first consideration in determining the joint diameters involves permissible mill tolerances on stainless tubing as purchased. Since silver brazing is generally used on thin tubing and such a specification is ASTM-A268, reference will be made to that specification in the following discussion. The actual permissible outside diameter tolerances are given in Table IV of that specification.

The second consideration involves permissible tolerances on socket joints that are commercially possible. Two ASA publications, B16.18 and B16.22, give such commercial shop tolerances for soft soldering and will be used as a guide in this discussion for silver brazing. It is to be noted in these latter two publications that the closest clearance on diameter is 0.002 in. for all sizes—this is a good practical rule to use. Two examples will be used to show how to determine the socket diameter.

For the first example, assume the tubing to be 1 in. OD. The mill tolerance for the tubing is ±0.005 in. The maximum OD of the tubing can therefore be 1.005 in. The minimum ID of the bore should be 0.002 in. greater or 1.007 in. Since the shop tolerance for such a bore is a total of 0.002 in., the bore diameter with tolerances would therefore be 1.007 to 1.009 in. The maximum possible clearance on a side could be (maximum OD bore − minimum OD tube)/2 = (1.009 − 0.995)/2 or 0.007in. which is a satisfactory clearance. This is the preferred method of determining the bore diameter. This is illustrated by Fig. 9.

For the second example, assume the tubing to be 3 in. OD. The mill tolerance is ±0.010 in. so the maximum OD could be 3.010 in. The shop total tolerance for this diameter is 0.0025 in. but use 0.003 in. in figuring. The bore of the socket would therefore be 3.012/3.015 in. The maximum possible clearance could be (3.015 − 2.990)/2 or 0.0125 in. which is a little high. It would therefore be better to base the bore on the minimum possible OD of tubing or 2.990

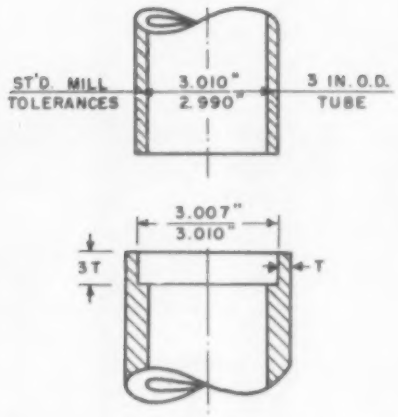


Fig. 10 Recommended design for 3-in. diam silver-brazed tube lap joint

in. and the desired 0.010 in. maximum clearance on a side. The maximum bore ID would be 2.990 + 0.020 or 3.010 in. The minimum bore ID would be 3.010-0.003 or 3.007 in. The maximum possible clearance on a side is now (3.010–2.990)/2 or 0.010 in. This is illustrated by Fig. 10.

If the tubing should be furnished with a total permissible overtolerance which is not usual, it would be necessary to grind or machine off a few thousandths, the amount depending on the actual bore and the actual OD of tubing.

Summary

1. Since mill OD tolerances on stainless-steel tubing are high as compared with the other metals, tests were made using commercial mill OD tolerances on stainless tubing and commercial practices in machining stainless-steel sockets for lap silver-brazed joints to determine at what stress failure occurred in the pipe or the lap.

2. These tests and calculations show that if the length of the lap of a silver-brazed joint according to a "rule of thumb" is made three times the thickness of the thinner wall, failure will occur in the tubing whether from internal pressure or tension stresses due to temperature expansion or dead load. This applies whether or not either part is of a different metal than stainless steel.

3. Joint clearances of 0.015 in. on a side are approaching a maximum and it would be best to limit this clearance to 0.010 in.

4. The user should satisfy himself, by appropriate tests, that his procedure and brazing alloy adapt themselves to the same convenient "rule of thumb." Failure should occur in the pipe when tested in direct tension since, when this condition is met, the joint will not fail when the tube is burst under pressure.

5. The user should be satisfied by tests, under actual operating conditions if possible, that the brazing alloy selected will make joints having corrosion resistance suitable for the intended use.[4]

6. The stainless steel should be in an annealed and not a severely cold-worked condition for silver brazing.

Acknowledgment

The author wishes to give credit for the test work and calculations to R. W. Schneider, former assistant design and metallurgical engineer and now with the Travelers Indemnity Co.

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APPENDIX
Derivation of Formulas

Case 1—Internal Bursting Pressure Governs

$$S_1 = H/A_1 \quad (1)$$

$$P = 2S_2T/D \quad (2)$$

$$A_1 = \pi DL \quad (3)$$

$$H = P\pi D^2/4 \quad (4)$$

Substituting eq 2 in 4

$$H = \frac{2S_2T}{D} \times \frac{\pi D^2}{4} = \frac{S_2T\pi D}{2} \quad (5)$$

Substituting eqs 5 and 3 in 1

$$S_1 = \frac{S_2T\pi D}{2\pi DL} = \frac{S_2T}{2L} \quad (6)$$

$$L = S_2T/2S_1 \quad (7)$$

Case 2—Direct Tension Governs

$$S_1 = K/A_1 \quad (1)$$

$$K = A_2S_2 \quad (2)$$

When T is approximately 10% or less in comparison with D:

$$A_2 = \pi DT \quad (3)$$

$$K = \pi DTS_2 \quad (4)$$

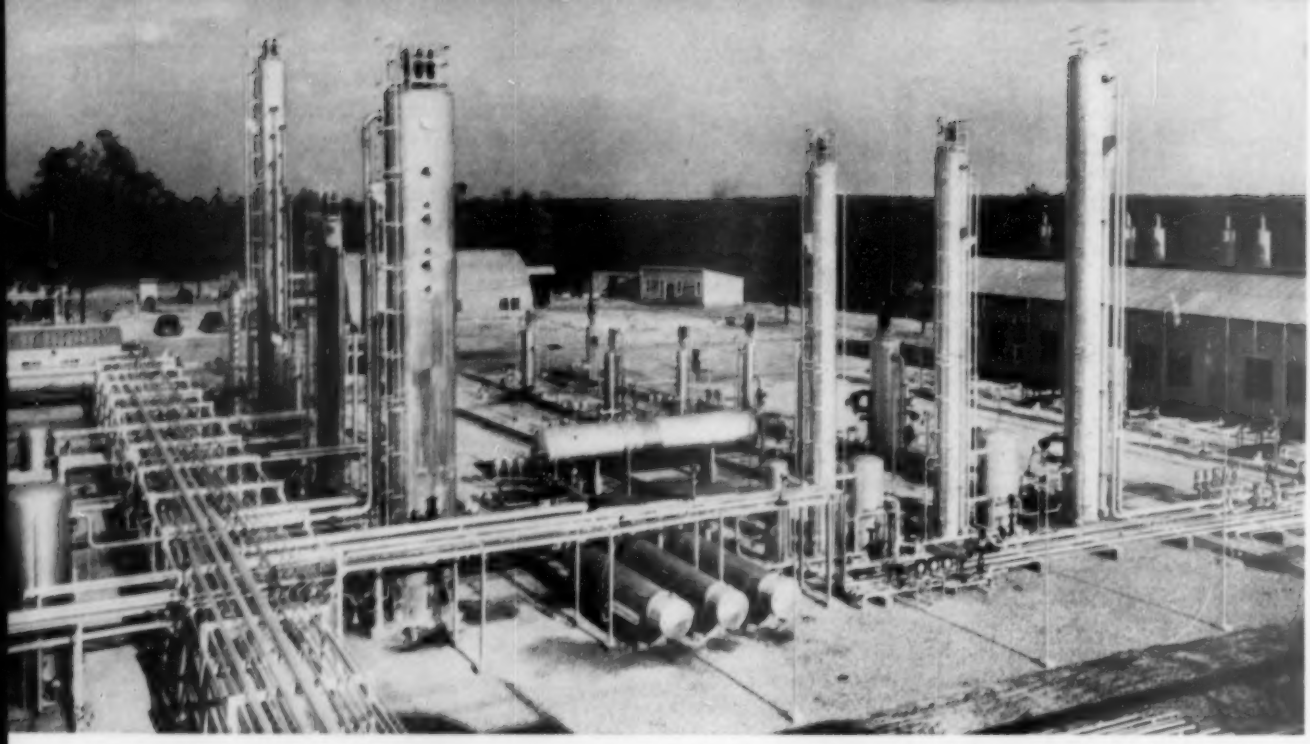
Substituting 2 and 4 in 1

$$S_1 = \frac{\pi DTS_2}{\pi DL} = \frac{S_2T}{L} \quad (5)$$

$$L = \frac{S_2T}{S_1} \quad (6)$$

Key

A_1 = shear area, sq in. (surface area of overlap)
A_2 = cross-sectional metal area of pipe, sq in.
H = end reaction due to bursting pressure, lb
K = ultimate tensile load of pipe, lb
L = length of lap, in.
P = bursting pressure of pipe, psi
S_1 = ultimate shear strength of brazing alloy, psi
S_2 = ultimate tensile strength of pipe, psi
T = wall thickness, in.
D = outside diameter when t is 10% or less than OD, if greater than 10%, use mean diameter of tube



The maze of pipes and tanks of the refinery and the towering derricks of the producing fields leave no doubt that the oil industry is big and important. To give components longer service life and to reduce down time in heavy-duty applications, users of equipment in this industry are turning more and more to welded and brazed hard-surface coatings

LONGER SERVICE LIFE THROUGH HARD SURFACING FOR PETROLEUM INDUSTRY EQUIPMENT

Hard-surface coatings have demonstrated their ability to resist the effects of the severe abrasive and corrosive conditions so frequently encountered in oil industry usage

BY H. S. GONSER

Introduction

Equipment used in the petroleum industry is exposed in normal everyday operation to extreme conditions of abrasion, corrosion, impact and galling. Such equipment, therefore, offers an interesting challenge in selection of materials.

Extensive research and development programs have been undertaken by petroleum producers, refiners and distributors. These programs are aimed at finding the best possible solution to material selection problems. Their investigations have covered everything available, including special alloying constituents, heat treatments and surface coatings.

Use of special alloy steels as well as certain heat treatments and metallized or plated surfaces has been found satisfactory in many applications. Welded hard-surface coatings, however, have demonstrated the greatest ability to resist the effects of the severe abrasive and corrosive conditions so frequently encountered in oil industry usage.

Hard Surfacing vs. Other Methods

Why is hard surfacing proving itself superior to other methods for improving service life of oil industry

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equipment? There are two basic reasons: first, the physical properties of hard-surfacing alloys are superior to surfaces obtainable with other materials or methods; and second, hard-surfacing alloys are joined to the base metal with a truly welded or brazed bond.

Hard-surfacing alloys in general have better wear and corrosion resistance than special alloy steels. The hard-surfacing alloy is made up of elements whose entire purpose is to provide such physical properties.

In a number of physical properties, alloy steels may overshadow hard-surfacing alloys, but in ability to resist abrasion and corrosion, hard-surfacing alloys excel. Because they are primarily intended for use as surface coatings, they need not sacrifice their special properties for the sake of gaining greater strength, ductility and toughness as is true of special-alloy steels or heat-treated materials.

This does not mean, however, that the hard-surfaced part itself will lack strength. Its toughness will be determined by the metal core to which the hard-surfacing alloy is applied. Most hard-surfaced parts

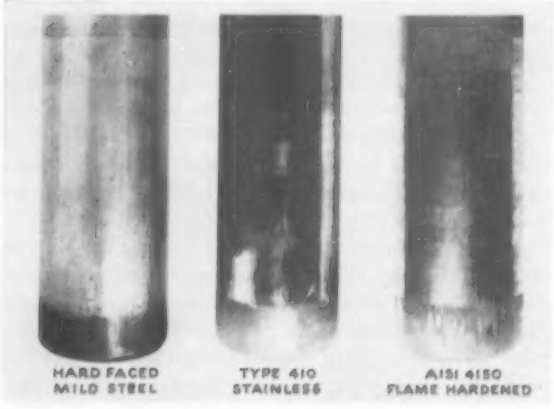

Fig. 1 Three pump plungers following a laboratory test to determine relative ability to resist salt water corrosion. The Type 410 plunger remained in service 13 days; scores and cracks developed which were sufficient to require replacement. The AISI flame-hardened part lasted but 2 days before pitting and scoring made it unserviceable. The hard-surfaced plunger showed no serious wear after 76 days in operation and was considered acceptable for continued service

utilize a low-cost core of mild steel. The required strength, ductility and toughness is provided by this core.

When trying to figure on paper what the service life improvement would be if you were to change over from an alloy-steel part to a hard-surfaced one, it is very difficult to nail down any realistic figure. There are just too many variables. Experience has shown, however, that in general hard-surfaced components last from three to twenty times as long as alloy-steel parts in identical severely-corrosive, severely-abrasive or severely-galling installations.

Plating, metallizing and other methods of surface coating also cannot compare with hard surfacing in rough service applications. The welded or brazed bond of hard surfacing is much more effective than the strictly mechanical bond achieved with the other methods.

As with all good things, however, there are a few drawbacks in the use of hard-surfaced mild steel. Initial cost is the largest single limiting factor. Hard-surfaced parts are usually more costly than those which are made of special alloys, although this depends greatly upon the type of steel involved; some alloy steels are also quite expensive. Sprayed-on hard surfacing also costs more than plating and metallizing, primarily because of the additional fusing operation required.

There is no simple rule-of-thumb that will tell an engineer whether he should use a special-alloy steel, a plated coating, metallized surface, or the protection of a hard-surfacing alloy. Each application must be thoroughly analyzed and total initial costs compared on the basis of anticipated service life. The best general guide is the service condition. If abrasion, corrosion or galling are severe, hard surfacing will probably be the cheapest in the long run.

Typical Hard-Surfacing Applications

Let's look at some typical applications to see where hard surfacing can be used economically. Figure 1 shows three pump plungers following a laboratory test to determine their ability to resist salt-water corrosion. The pumps in which these plungers are installed are used for waterflooding with salt water. Waterflooding is a process whereby water is injected into oil reservoirs to supplement depleted gas pressure, thus increasing the percent of select crude oil recoverable.

The plungers are 3-in. in diameter. The plunger on the left is a mild-steel part protected with a sprayed and fused hard-surfacing alloy. The alloy in this case is a nickel-base material containing chrome borides. The center plunger is made of hardened Type 410 stainless steel having a Rockwell C-scale hardness of 48. The right-hand plunger is a flame-hardened AISI 4150 steel part whose hardness is 60 Rc.

The Type 410 plunger remained in service for 13 days before scores and cracks developed to a degree that dictated replacement. The AISI 4150 part lasted but 2 days before pitting and scoring made this plunger unserviceable. The hard-surfaced plunger, on the other hand, showed no serious wear after 76 days in operation and was considered acceptable for continued service.

The fluid used in the tests was a very corrosive oxygenated synthetic brine containing 65,000 ppm of sodium chloride, 3000 ppm calcium chloride and 1000 ppm magnesium chloride. Fluid temperature was maintained at 120° F. The pump was operated at 750 psi pressure at a speed of 265 rpm.

Coated compressor rods are another example of

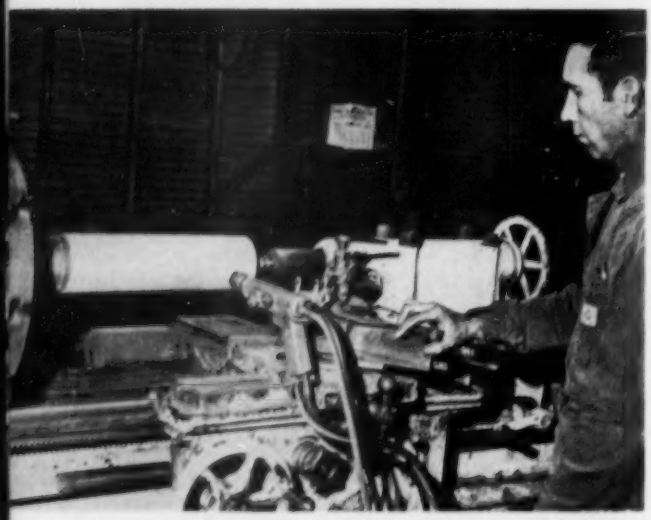

Fig. 2 Typical setup for applying sprayed and fused hard-surface coatings. Alloy powder is fed into the pistol unit which is traversed by the lathe's feed mechanism as the part rotates

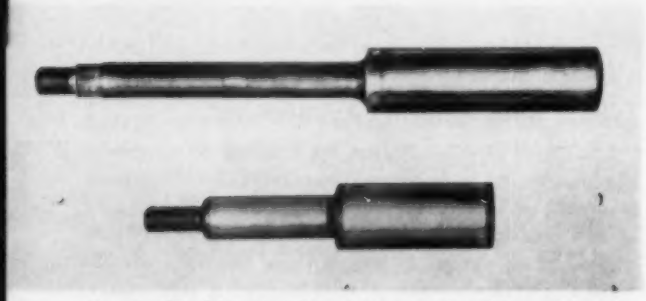

Fig. 3 (*Top*) Hard-surfaced plunger after 22 months' service in a salt water application. Packing maintenance was practically eliminated through use of the hard surface alloy protection. (*Bottom*) Pump plunger that had been in continuous refinery service for more than a year pumping dilute hydrofluoric acid

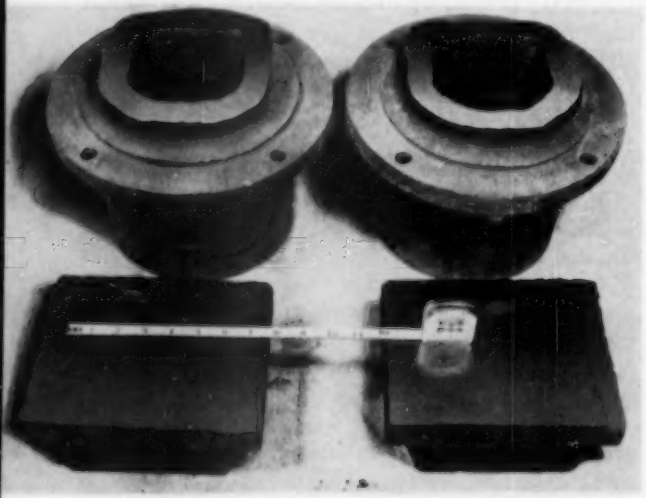

Fig. 4 Catalyst slide valve components which have been protected by hard surfacing. These units have displayed an improvement of 5 times the service life over unprotected valves

hard surfacing successfully applied. Rods and plungers are generally hard surfaced by spraying and fusing using a set-up similar to that shown in Fig. 2. Alloy powder is fed into the pistol unit which is traversed as the part rotates in the lathe.

When hard surfacing was applied to compressor rods used in an 800-psi hydrogen application, life was more than tripled. The rod is fabricated of 1035 carbon steel. Prior to the use of hard surfacing, chrome plating had been tried. The surface generally lasted approximately 6 months. At last report, hard-surfaced rods had been in service for more than $1^1/_2$ years without trouble.

Another salt-water application is the hard-surfaced pump plunger at the top in Fig. 3. This part was removed from the pump and photographed after 22 months' service in Oklahoma. One very interesting part of this user's experience was that packing maintenance was practically eliminated during the entire period. Packing life increase is one of the outstanding advantages of hard-faced surfaces that is often overlooked. Reductions in packing maintenance can produce substantial cost savings in any installation. This plunger replaced one that had lasted no longer than 4 months, and which required daily packing gland maintenance.

The lower plunger in Fig. 3 is one that had been in continuous refinery service for more than a year pumping dilute hydrofluoric acid. Uncoated plungers had lasted from 60 to 90 days in this severely corrosive application. The overlay on the hard-surfaced plunger was 0.045 in. thick.

The examples cited up to this point bear out the corrosive resistant abilities of hard surfacing. Since all four are either rods or plungers, it may be observed that corrosive effects are aggravated by the type of wear associated with reciprocating motions. This is true, but the friction that accelerates surface breakdown in such corrosive atmospheres need not be linear in nature. Rotary motions can also induce a similar condition. Pump plungers and compressor rods were among the first oil-field applications and are still the most common.

Among more recent applications are tapered plug-line valves and the catalyst slide valve components shown in Fig. 4. The catalyst valves when protected by hard surfacing have displayed an improvement of 5 times the service life experienced with unprotected units. These valves are subject to severe erosion caused by the scouring action of the catalytic materials handled. These catalysts may be used either in fluid form or in dry form as shot or pellets.

One of the most interesting applications of hard surfacing from the standpoint of operating conditions is on acidizing pump plungers. In acidizing, a mixture consisting basically of a combination of special sand and dilute hydrochloric acid is pumped into acid-soluble petroleum formations to increase permeability. Acid content normally varies from 1 to 15% by volume. Here we have a material that offers one of the nastiest

possible combinations of corrosiveness and abrasiveness. Corrosion from the dilute hydrochloric acid, which is well known for its etching effect on metals; and abrasion from sand. To curtail the corrosive action of the acid, producers of these acid-sand emulsions add chemical inhibitors to prevent corrosion of metal well equipment. It is therefore the abrasiveness of the sand particles that causes the most trouble in acidizing pumps.

In the search for a suitable means of prolonging service life, every possible material and technique was tested. Hard-chrome plating, various steel alloys, different heat treatments and hard-surfacing materials were all tried and compared for effective abrasion resistance. Hard surfacing demonstrated the greatest ability to resist the severe sand abrasion conditions. Figure 5 shows an operator fusing the hard-surface coating on the plunger.

The improvement in service life is demonstrated by a comparison of hard surfacing with a heat-treatable material. The heat-treated steel showed ability to handle up to 12,000 gal of acidizing mixture before replacement was required. Mild-steel plungers coated with a hard-surfacing alloy, on the other hand, are currently pumping as much as 125,000 gal between pump overhauls. Service life is more than ten times as great.

The Future of Hard Surfacing

Hard surfacing as a means of improving service life of parts used in heavy duty petroleum applications has made great strides during the past ten years or so. But we are only beginning to scratch the surface. Many possible applications are just in the talking stage; a number of others have reached the experimental stage and are undergoing laboratory and field tests. A couple of these "test tube babies" may be worth mentioning.

Reactor grid inserts or baffles show considerable promise of being well suited to the use of protective hard-faced surfaces. These inserts are used in catalytic cracking units and must handle abrasive catalysts which may be of either a dry or liquid type. The hard-surfacing alloy is applied by oxyacetylene welding. The hard-surfaced parts are designed to replace those fabricated of heat-treated steel. Laboratory tests have been completed and a quantity of inserts are now in field test installations in various parts of the country. Preliminary reports of potential service life have been most encouraging.

Other experimental projects are under way on a couple of components for deep well pumping units. Hard surfacing has proved its effectiveness in other parts of this equipment and its success there led to its consideration as a possible solution to additional wear problems.

In these reciprocating deep well units, a long string of so-called "sucker rods" is inserted in the hole to literally lift the oil to the surface. These rods are joined together to form sections about 60 ft long.

Fig. 5 Fusing a pump plunger which has been sprayed with hard-surfacing alloy powder. This part is used in an acidizing pump where a mixture of sand and dilute hydrochloric acid is pumped into well formations to improve permeability. Plungers so protected outlast ten fabricated of heat-treated steel

The sections are connected by means of internally threaded sucker rod couplings. Figure 6 shows schematically a sucker rod coupling joint. When the sucker rods must be pulled from the hole, the string must be broken at each coupling. Frequently, because the sucker rods and couplings are fabricated of similar materials, galling at the joint makes the coupling difficult to break.

Under test at the present time is a break-out ring that is inserted between one end of the coupling and the sucker rod. Figure 7 shows schematically this arrangement. This ring has one face protected with hard-surfacing alloy. The theory is that the excellent galling resistance of the hard-faced surface will make disconnection quick and easy. Laboratory and field tests to date have shown this to be a very satisfactory design.

The other experimental part for which hard sur-

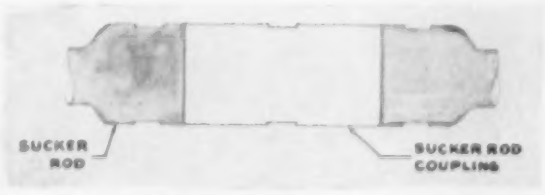

Fig. 6 Schematic drawing of conventional sucker rod coupling arrangement

facing has recently been tried is a ball check valve which is used in quantity in deep well pumping units. The valve consists of a metal ball and a metal seat. These valves must handle crude oils containing high percentages of sand and—in many fields in the southwest—hydrogen sulfide. They are therefore subjected to severe conditions of abrasion and corrosion.

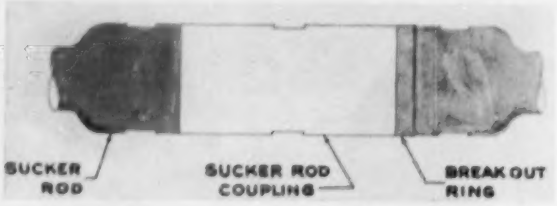

Fig 7 Schematic drawing of experimental sucker rod coupling arrangement using a hard-surfaced break-out ring to eliminate the possibility of galling between rod and coupling

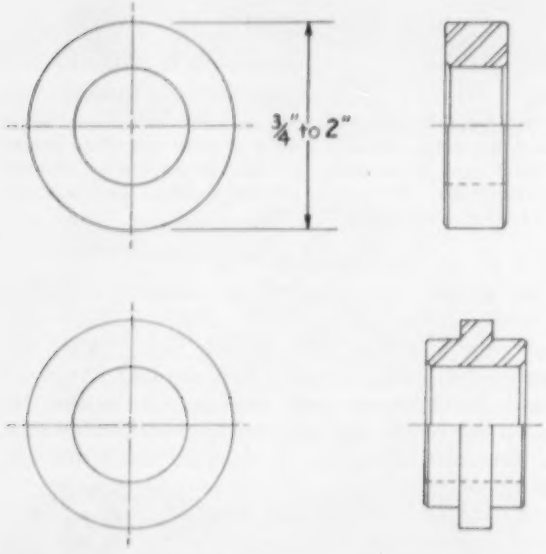

Fig. 8 Drawing of two common forms of check valve seats used in deep well pumping units

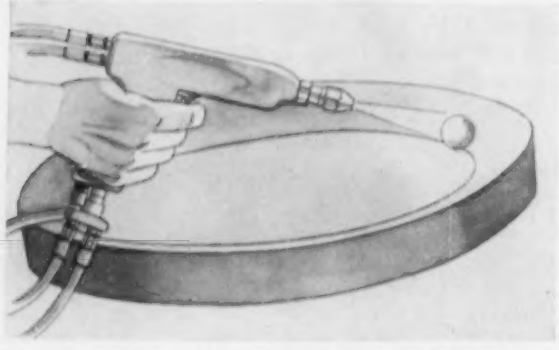

Fig. 9 Drawing of the type of setup used in experimental attempts to apply hard-surfacing alloy to check valve balls by spraying

This application is interesting because of the fact that hard-surfacing alloy would appear to be the answer to the wear problem, but the hard-surfacing process itself is not practical. Explaining this, check valve seats are used in two common forms as illustrated in Fig. 8. The size range indicated (3/4- to 2-in. diameter) must be noted. This is a part that could be made of mild steel and hard surfaced, but because of its size is much better made of a hard-surface alloy casting.

Progress in this direction has been going on for a number of years, but completely satisfactory results have not as yet been achieved. The latest hard-surfacing alloy to be tried is a nickel-chrome-boron material that holds promise of answering the need.

Experimental castings have been made, have undergone analysis and are now being tested. One report from a test installation states that a valve seat cast of nickel-chrome-boron has outlasted three chrome-cobalt-tungsten castings and is still in service.

The ball presents a problem in hard surfacing because of its shape. We have considered spraying the ball as it is rolled within a dished enclosure, propelled by the jet action of the spray as it comes from the metal-spraying gun. The drawing in Fig. 9 shows the type of set-up we used for this experiment. An oval dish had to be employed to keep the ball from overspeeding. Overspeeding caused extreme difficulty in tracking with the spraying gun.

The main problem with this method is the difficulty in maintaining tolerances and in obtaining a uniform coating. But even if we assume that adequate coverage can be achieved, an even more difficult problem is presented in the matter of fusing the hard-surfacing alloy. It may be possible to devise special equipment for fusing, but it appears that the cost would be prohibitive.

This is another case where the most practical solution seems to lie in making the balls as castings of hard-surfacing alloy. The first of the check valves with both ball and seat cast of nickel-chrome-boron hard-surfacing alloy was installed for on-the-job testing in a deep well pumping unit in July 1956. Reports to date are very satisfactory.

The examples presented in this paper emphasize the fact that hard surfacing is definitely a process for original equipment application. Although it first got its start and gained acceptance as a reclamation process, it now has achieved the stature of a proved method in the production of components for the petroleum industry. It deserves careful consideration as a means of lengthening service life, particularly in severe applications. Or, looking at it another way, it is a means of reducing equipment down time.

As competition in the petroleum industry increases, down time for replacement and repair is bound to become more and more critical. In such a competitive picture, the future looks bright for the use of welded and brazed abrasion and corrosion-resistant surfaces for petroleum industry equipment.

Portable arc spot production setup with removable and adjustable work table

BY J. W. KEHOE AND H. J. BICHSEL

INERT-GAS-SHIELDED METAL-ARC-SPOT PROCESS

Standard inert-gas-shielded metal-arc welding equipment has been modified whereby in addition to regular inert-gas metal-arc welding, a controlled time and localized arc spot can be obtained

Introduction

Inert-gas-shielded metal-arc equipment was introduced several years ago when both manual and fully automatic equipment was made available. The difficulty to weld nonferrous materials such as aluminum, copper, copper alloys and the austenitic stainless steels were successfully welded by this process using argon, helium and combinations of these inert gases. Successful welding of mild steel became possible with the introduction of "killed steel" wires and special coatings recently.

Recent modifications to most of the commercially available types of inert-gas metal-arc equipment now make it possible to make short-timed localized welds in the form of plug, fillets, outside corners, or butt welds in addition to its being used as a standard welding tool. This together with the use of CO_2 gas as well as argon, helium and intermixes of the latter two has opened up new fields of lower cost fabrication plus definite cost reduction possibilities on existing designs. In addition to ferrous materials, principally mild steel, the "arc spot" process is applicable to most of the commonly welded aluminum alloys and austenitic stainless steels.

Fig. 1 Semiautomatic gun and wire drive control from which spot welding equipment was developed

Equipment

The equipment for performing arc spot welds is an adaptation of the semiautomatic or manual inert-gas-shielded metal-arc gun and wire drive unit shown in Fig. 1.

Two types of special nozzles were developed for the gun. One type slips over the nozzle and is intended for short-run work or work where it is necessary to

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change nozzles rapidly and frequently (see Fig. 2). The second type is a set of nozzles which replaces the standard nozzles on the gun. They are fastened to the gun by an adapter and a threaded ring as shown in Fig. 3. These nozzles are water-cooled and are more suited to production work where many identical welds are to be made and where the duty cycle is high. Nozzles for plug welds, inside corners and outside corners or fillet welds are available in both types (see Fig. 4)

The following changes were made in the standard wire drive control:

1. Automatic inching of wire.
2. Preweld gas purging.
3. Welding timing.
4. Wire "burn-back" control.
5. Selector switch for manual, automatic or spot welding.

When the trigger of the welding gun is pulled, welding wire is inched slowly toward the work. Control of the inching speed is achieved by a potentiometer in the grid circuit of the thyratron tube which controls the wire feed speed. This control is, in effect, the preweld gas purge timer. If the inching speed is low, a long purge time is achieved and, conversely, the purge time is short if the inching speed is high. When the welding wire strikes the work, welding current flows and a current relay in the control transfers the wire speed control from the "inching speed control" to the "welding speed control" which is in the gun. Weld timing is also initiated by the current relay.

Weld timing is accomplished with a pneumatic timing relay which is calibrated from 8 to 360 cycles. For most applications, this type of timing device has proved satisfactory; however, several applications have been encountered where more accurate timing was required. In these cases, a NEMA Type IA electronic timer is employed.

To prevent the welding wire from sticking in the molten pool, the wire must be "burned-back" at the end of each weld. This is accomplished by a fixed time delay relay (capacitor type) in conjunction with adjustable dynamic braking in the feed motor armature circuit. On small diameter wires (0.040) which are driven at speeds up to 600 ipm, the braking resistor is set at a low value for rapid stopping. As the wire size is increased the value of breaking resistance is increased and adjusted so that the desired burn-back is obtained on the wire after each spot.

The above equipment is mounted on the door of the wire drive control. Standard equipment can be converted to spot welding equipment in a few minutes by removing the original door and replacing it with the new door as shown in Figs. 5 and 6. Electrical connections are made on a terminal strip inside the control cabinet.

The control sequence circuit is designed to be nonbeat and nonrepeat (see Fig. 7). Once the gun trigger is pulled, a complete weld will be made even though the trigger is released in the middle of a weld. The trigger must be released after each weld and pulled again to initiate the next weld.

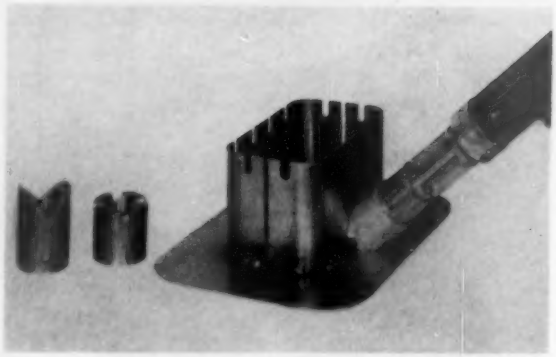


Fig. 2 Slip-over air-cooled nozzles for spot gun being used to weld pole-boxes for mill motors

Fig. 3 Water-cooled nozzle for spot gun

Fig. 4 Water-cooled plug, corner and fillet nozzles

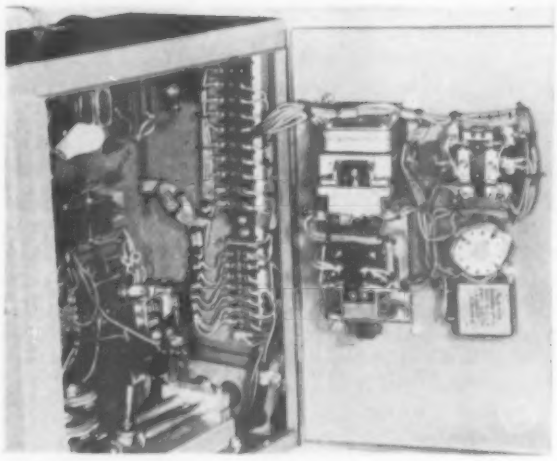
The gun and wire drive control equipment are designed to operate in conjunction with a constant potential rectifier welder as shown in the lead photograph. The welder originally developed for use with the semiautomatic welding gun performs very well on arc-spot-welding operations. This welder has a current rating of 650 amp at 60% duty cycle. Its output voltage is adjustable from 14 to 40 v. Its output characteristic is essentially flat having a drop of less than one volt per hundred amperes.

The use of a constant-potential welding machine is desirable for several reasons:

1. The lower arc voltages as compared to those ob-

Fig. 5 *Left:* Front view of wire drive control equipped with timer for spot welding

Fig. 6 *Below:* Inside view of wire drive control showing equipment required for spot welding on front door and interconnection terminal board in cabinet at right top



tained from other power sources makes the welding arc less critical and gives little or no burn-back such as experienced with higher arc voltages from other types of power sources.

2. With the particular equipment shown in Fig. 3, the readily accessible wire-feed adjustment in the handle of the gun can only be utilized on a constant-potential type of power source as a current control.

The welder is equipped with a primary contactor and an auxiliary relay for operating it. A 1-kva transformer in the welder supplies 110 v ac for operating the control. Receptacles are provided on the welder for connecting both the 110 leads to the control unit and the leads from the control which energize the auxiliary relay in the welder.

In addition to the gun, wire drive control and welder, a source of cooling water, a water drain, gas cylinder, gas regulation and flow meter and gas and water hoses are required. Standard stationary equipment may be used where the equipment is to be installed in a booth for high production welding. In many shops, the versatility of this equipment can best be exploited by mounting the equipment on a rubber tire running gear so that it can be moved from one location to another in the shop. Such a unit is shown in the lead photograph and in Fig. 8. In this case, a 40-gal water tank and recirculating pump are used to supply the cooling water. All electrical, gas and water connections are made at the factory. A power source of 220/440 v, 3-phase ac is required to operate the unit. No water connections are required.

Applications

(a) *Mild Steel*

On applications where intermittent welding is required—this can be done by means of plug, fillet, butt or corner welds using the slip-on nozzle design which when its use is completed, can be readily removed and regular manual welding employed. Figure 9 shows several examples. The angle to sheet assembly as shown is a $^1/_4$-in. thick angle $1^1/_2$ x $1^1/_2$ having $^1/_2$-in. holes plug welded to $^1/_8$-in. thick sheet with no surface indentation on the outside surface of the sheet. This

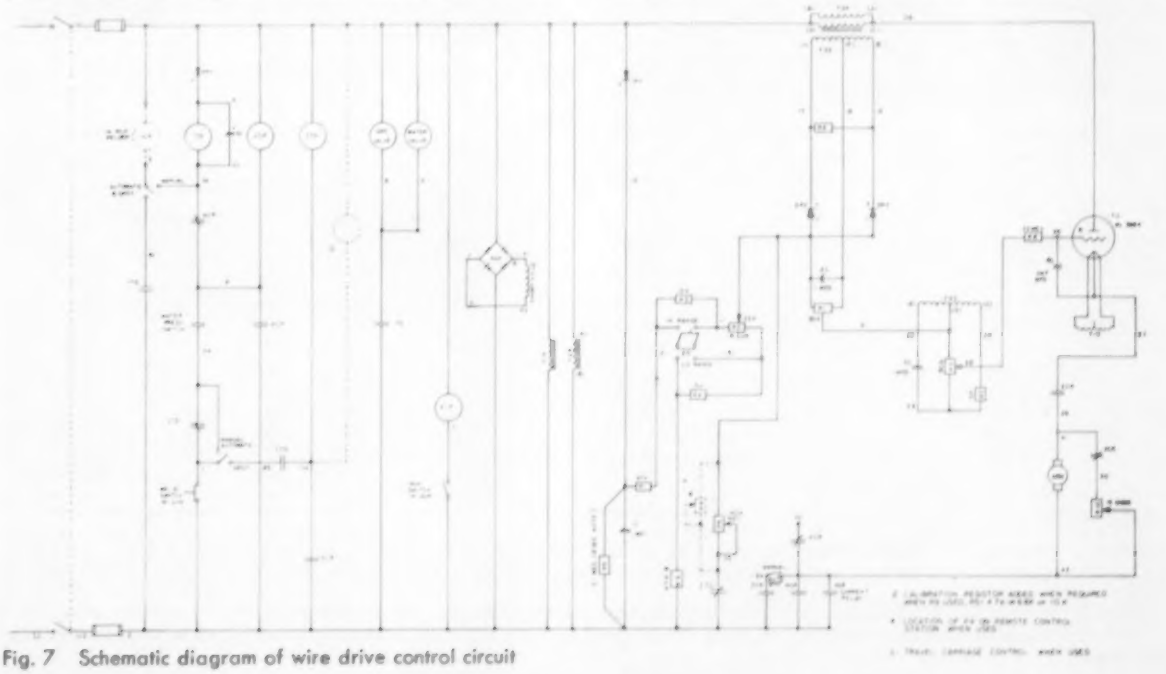


Fig. 7 Schematic diagram of wire drive control circuit

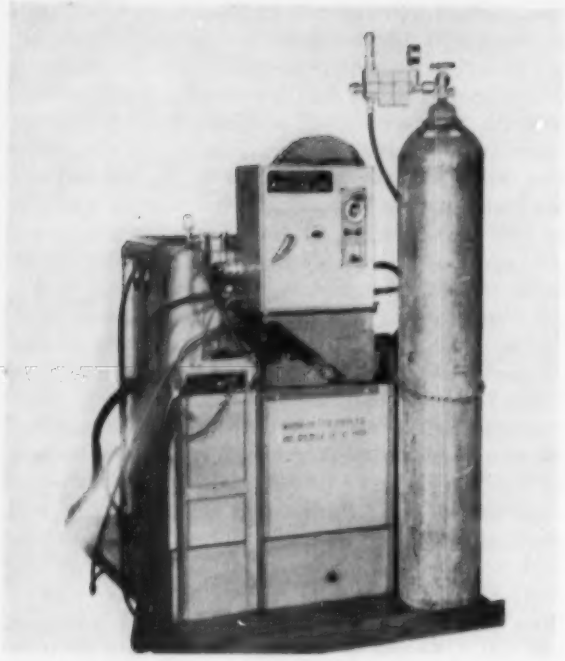


Fig. 8 Rear view of portable arc spot welding unit

could also be done with fillet-spot welds but plug welds were found to give a tighter sheet to angle combination. Each weld in tensile-shear averages 5400 lb, whereas the fillet welds are 3400 lb. The two lower left-hand applications are fillet tack welds which can be welded over with the standard inert-gas-shielded metal-arc process without any cleaning of these fillet or "facility welds." The lower right-hand assembly represents a corner weld which can be made by using a corner nozzle. Above this is a foot-bracket plug welded to a typical round industrial motor frame. This assembly was formerly resistance projection welded on a 1000-kva projection welder. The plug application as shown requires 410 amp at 85 cycles of weld timer per plug weld. The equipment cost differential is readily apparent in favor of the new arc spot process.

Where plug and corner welds are made, the use of low consumption rates of argon and preferably argon with 1 and/or 2% oxygen content and straight polarity can be successfully applied. It has been found possible on thicknesses up to 2 pieces of 0.188 mild steel that strong ductile welds can be made by welding directly through one thickness (that in contact with the gun nozzle) without resort to a hole in that particular

Table 1—Overlap Plug Welds—Mild Steel

Thickness combination, in.	*Hole size diam, in. (Note 1)*	*Minimum overlap and width, in.*	*Tensile shear total load, lb (Note 3)*	*Arc welding current, constant potential welder, straight polarity*	*Arc welding time, cycles*
0.064-0.064	3/8*	1	3000	410	50
0.078	3/8	1	3100	410	50
0.125	3/8	1	3400	410	50
0.188	3/8	1	4500	410	50
0.250	3/8	1	4600	410	50
0.078-0.064	3/8	1	3200	410	55
0.078	3/8	1	3400	410	55
0.125	3/8	1	4200	410	55
0.188	3/8	1	4700	410	55
0.250	3/8	1	5000	410	55
0.125-0.064	3/8	1	3200	410	65
0.078	3/8	1	3300	410	65
0.125	3/8	1	4700	410	65
0.188	3/8	1	6300	410	75
0.250	3/8	1	6400	410	85
0.188-0.064	1/2†	1 1/4	4300	440	85
0.078	1/2	1 1/4	4800	440	85
0.125	1/2	1 1/4	4900	440	90
0.188	1/2	1 1/4	6400	440	90
0.250	1/2	1 1/4	6500	440	90
0.375	1/2	1 1/4	8000	440	205
0.250-0.064	1/2	1 1/2	4000	460	105
0.078	1/2	1 1/2	4500	460	110
0.125	1/2	1 1/2	5400	460	115
0.188	1/2	1 1/2	5500	460	120
0.250	1/2	1 1/2	7700	460	130
0.375	1/2	1 1/2	7800	460	250
0.375-0.375 (Note 2)	5/8	1 1/2	8000	460	500

* Gas flow, 1% oxygen-argon, 8 cfh for all 3/8-in. hole sizes. † Gas flow, 1% oxygen-argon, 10 cfh for all 1/2-in. hole sizes.

Note 1. In all cases the sheet size in combination with the other thicknesses is the sheet nearest the gun nozzle and also the pierced sheet. For example: (*a*) thickness combination, 0.078-0.064, the 0.078 thickness has a 3/8-in. hole punched in it and is the thickness in contact with the nozzle.

Note 2. Welding of 0.375 material to 0.375 requires two consecutive weld times of 250 cycles each.

Note 3. These tensile shear values were obtained on test pieces having a width and overlap equal to that of recommended overlap and width.

Table 2—Overlap Fillet Tack Welds—Mild Steel

*Thickness combination, in.**	*Fillet length average, in.*	*Minimum overlap, in.*	*Tensile shear total load, lb* †	*Arc welding current, constant potential welder, straight polarity*	*Arc welding time, cycles*
0.125-0.064	5/16	1/2	1700	390	25
0.078	5/16	1/2	2700	390	30
0.125	5/16	1/2	3000	390	40
0.188	5/16	1/2	3400	390	50
0.250	5/16	1/2	4200	390	60
0.188-0.064	3/8	1/2	1700	350	50
0.078	3/8	1/2	2200	350	50
0.125	3/8	1/2	2300	350	55
0.188	3/8	1/2	3000	350	60
0.250	3/8	1/2	3800	350	70
0.250-0.064	3/8	1/2	2300	375	50
0.078	3/8	1/2	2500	375	55
0.125	3/8	1/2	3400	375	60
0.188	3/8	1/2	3800	375	70
0.250	3/8	1/2	4000	375	80

* Gas flow, 1%-argon, 8 cfh for all combinations shown.
† The above tensile shear values were obtained on test pieces having a width equal to the recommended minimum overlap.

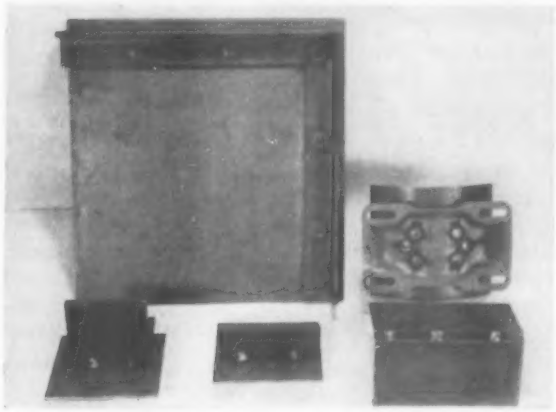


Fig. 9 Mild steel application of arc-spot plug, corner and fillet welds

Fig. 10 Arc-spot plug welded frame assembly consisting of three pieces of 1/4-in. thick steel weighing 50 lb. Each end piece has 1/2-in. diam punched holes used for plug welding to the cross member. Other holes are for locating purposes and have no relation to the arc spot method

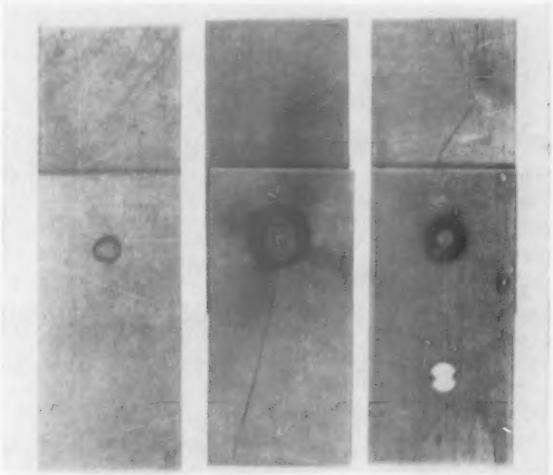


Fig. 11 Plug welds on two pieces of 1/8-in. mild steel, showing 3/8-in. hole prior to welding, as welded, and the outer or finished surface

thickness and using welding grade CO_2 gas and reverse polarity. There is a surface build-up of filler wire often equal to the thickness of the top sheet.

Heavy items can be assembled on bench, floor or bedplate fixtures without having to be handled by special handling mediums or several operators, such as might be required, if the work has to be brought to the machine, such as in a resistance spot-welding operation. Figure 10 illustrates this point.

Tables 1, 2 and 3 show data using argon gas with 1% oxygen, straight polarity, and holes in the top sheet in contact with the gun, which are plug welded, fillet and butt tack welds, respectively. Table 4 shows information for welds made through the top sheet using CO_2 gas. Figure 11 shows plug welds on 2

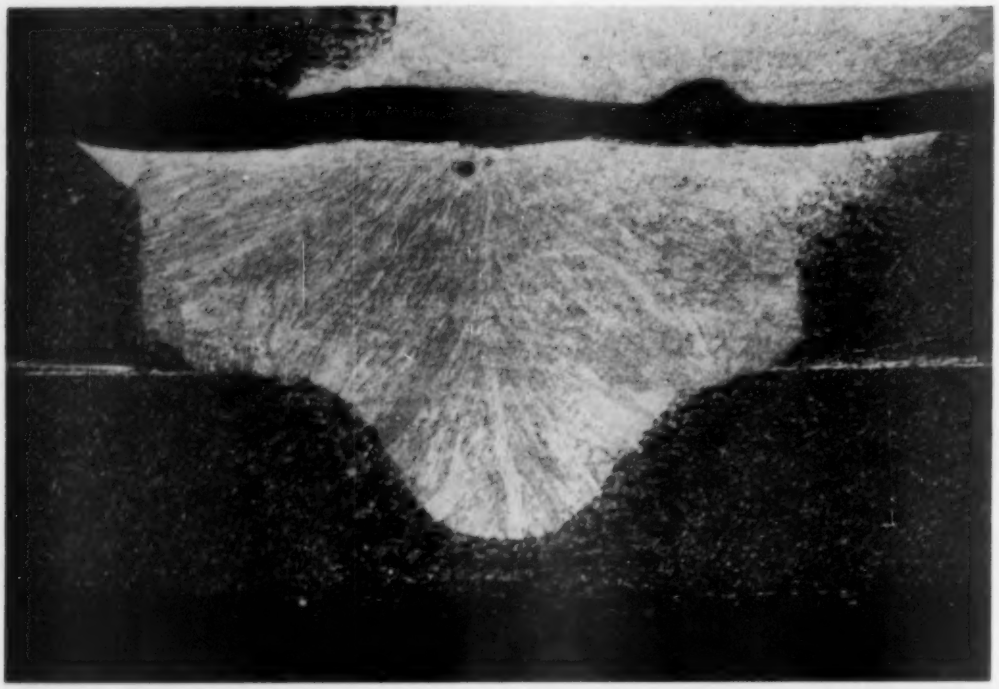


Fig. 12 Photo-macro of a plug weld on 2 pieces of $^1/_8$-in. steel (X 10)

pieces of $^1/_8$-in. mild steel, illustrating a $^3/_8$-in. hole in the left assembly, the actual weld in the center assembly and the opposite or front surface which is not in contact with the gun nozzle. Figure 12 shows a photo-macro of the weld shown in Fig. 11. Figure 13 illustrates a CO_2 arc spot weld on 2 pieces of $^1/_8$-in. mild steel. The left assembly shows the welded side and the right assembly the outer or finish side. Figure 14 shows a photo-macro of the weld shown in Fig. 13.

(b) *Aluminum Alloys*

The aluminum alloys which are normally inert-gas metal-arc welded can be plug, fillet, butt and corner welded with the arc spot process using reverse polarity. The strengths of aluminum plug welds are lower than those obtained with expensive resistance spot-welding equipment by comparison to MIL specification standards. Yet it is possible to weld narrower widths and overlaps with the arc-spot-plug process than that required for the resistance-spot process with no marking on one side.

For example, Fig. 15 shows three illustrations. The lower assembly is a $^1/_2$-in. wide, $^1/_{16}$-in. thick 3003 aluminum sheet with a $^1/_4$-in. hole on one thickness. The overlap used was $^1/_2$ in. The tensile shear strength of this assembly was 400 lb. The middle application represents two thicknesses of 3003 aluminum material $^1/_8$ in. thickness, having a 1-in. width and overlap and a $^3/_8$-in. hole in the one thickness. Average tensile shear of this combination was 1000 lb. The upper assembly of Fig. 15 illustrates a $^1/_4$-in. diam E.C. (electrical conductivity—high purity) aluminum bar plug welded to a $^1/_8$-in. thick aluminum sheet. The weld is shown on the left of the assembly and the joint preparation on the right. The same plug nozzle used on the $^1/_8$-in. thick aluminum assembly below was used on this particular bar-sheet assembly.

Table 3—Butt Joint Tack Welds—Mild Steel

*Thickness combination, in.**	*Butt joint opening, in.*	*Tensile total load, lb*	*Arc welding current, constant potential welder, straight polarity*	*Arc welding time, cycles*
0.064–0.064	None	1700	375	25
0.078–0.078	None	2400	375	35
0.125–0.125	$^1/_{16}$	3600	375	50
0.188–0.188	$^1/_8$	4000	375	65
0.250–0.250	$^1/_8$	4500	400	80

* Gas flow, 1% oxygen-argon, 8 cfh for all combinations shown.
Average width of test pieces was 1 in. in all cases.

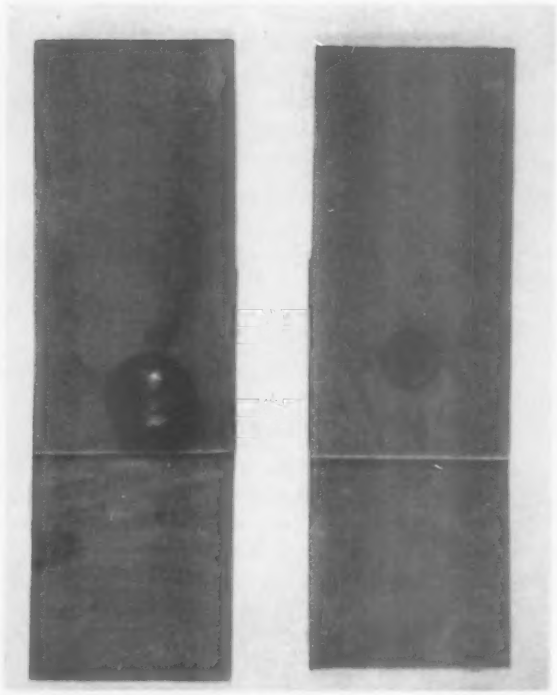


Fig. 13 CO_2 arc spot welds on two pieces $^1/_8$-in. mild steel, showing weld made through top sheet and the outer or finished surface. No hole required

Figure 16 shows a cluster of aluminum conductors welded with the identical plug nozzle referred to in Fig. 15. To the right of this assembly is shown a typical fillet or inside corner weld made on $^1/_8$-in. aluminum sheets.

The chief differences in equipment details in arc-spot welding aluminum over steel are:

1. A nylon liner in the gun cable assembly for the softer aluminum wire is required.
2. Maximum recommended length of welding cable is 10 ft because of the low column strength of the soft aluminum wire.
3. An electronic timer has been found to be desirable.
4. Straight argon or helium gas or intermixes are more desirable than those gases used for mild steel. Straight CO_2 gas is not suitable for use on aluminum.

(c) *Stainless Steels*

A very limited amount of work done to date indicates that the austenitic stainless steels which are readily weldable can be suitably arc-spot welded in plug, fillet, butt and corner welds. The same stainless

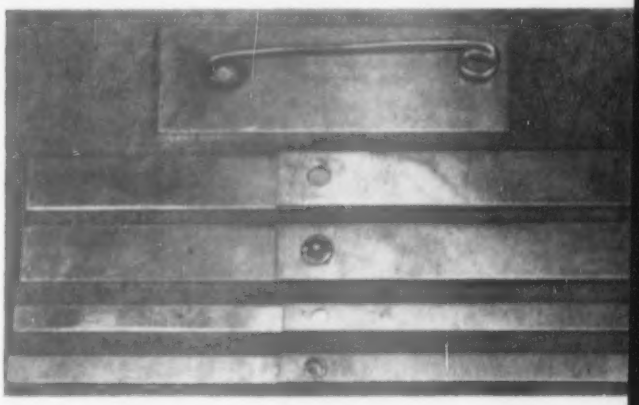


Fig. 15 Aluminum arc-spot-plug welds

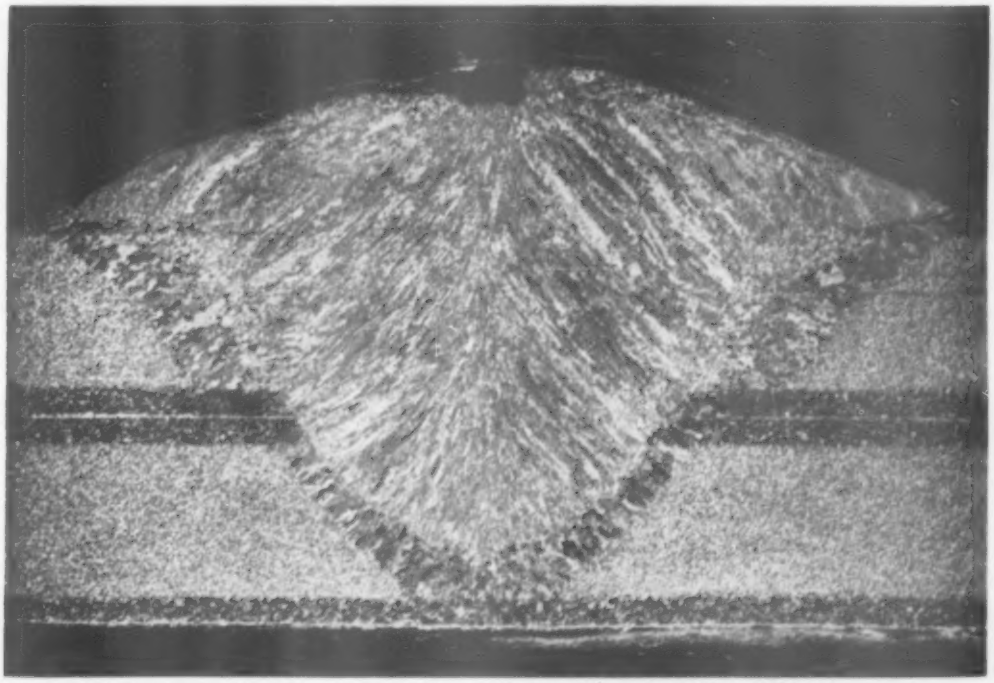


Fig. 14 Photo-macro of a CO_2 arc-spot weld on two pieces $^1/_8$-in. thick rim steel (X 10)

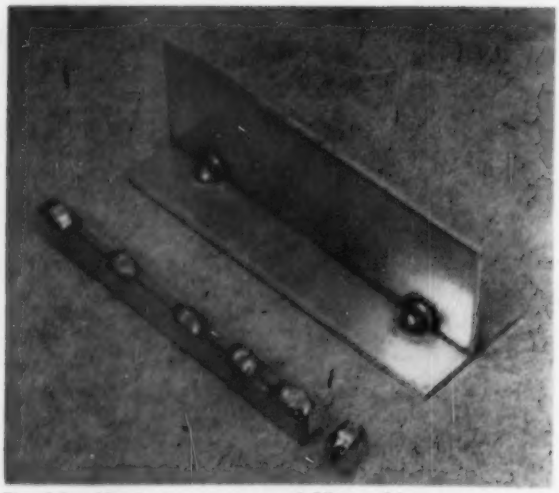


Fig. 16 Aluminum arc spot and fillet welds

filler wires recommended for welding are used in the arc-spot process. Likewise, a more accurate electronic type control, and preferably argon and/or helium instead of CO_2 gas, has been found applicable to these materials. Application of any type of arc spot weld to critical applications or to the crack-sensitive type of austenitic stainless steels should not be made without extensive development and test work.

Conclusions

The specific advantages of the arc-spot process on mild steel, aluminum and austenitic stainless are in common, itemized and differentiated as follows:

1. Inert arc-spot welds can be made from one side in the form of plug, outside corner, butt and fillets (inside corners). Where overlap spot welds on mild steel are desired, CO_2 shielding gas is recommended. In the case of mild steel, welds can also be made through the top thickness into 35–50% of the lower thickness using welding grade CO_2 gas and reverse polarity.

2. Material in the as-received condition can be inert arc-spot welded. Regular black mill scale and *normal* oil condition on mild steel have no detrimental effects on weld quality. Aluminum and stainless steels should be degreased—no chemical cleaning is required.

3. No cleaning is required after welding as a result of the inert arc-spot weld operation.

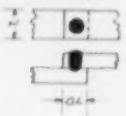
4. Mild steel and stainless steel can be arc-spot welded with no limitations in single thickness between $^1/_{16}$ and $^3/_8$ in. Figure 17 shows a before-and-after example showing a plug weld application on two pieces of $^1/_8$-in. aluminum. Note the smooth appearance on the thickness without the hole. This could be considered a front panel. Aluminum has been successfully welded in thicknesses between $^1/_{16}$ and $^1/_4$ in. using 4043S filler wire.

5. The welds are automatic in so far as the arc time can be controlled at a fixed value which can be adjusted from 8 to 360 cycles.

6. Less operator protective shielding is required than with any other arc process; no *special* helmets, clothing or gloves are required.

7. No special operator skill is involved.

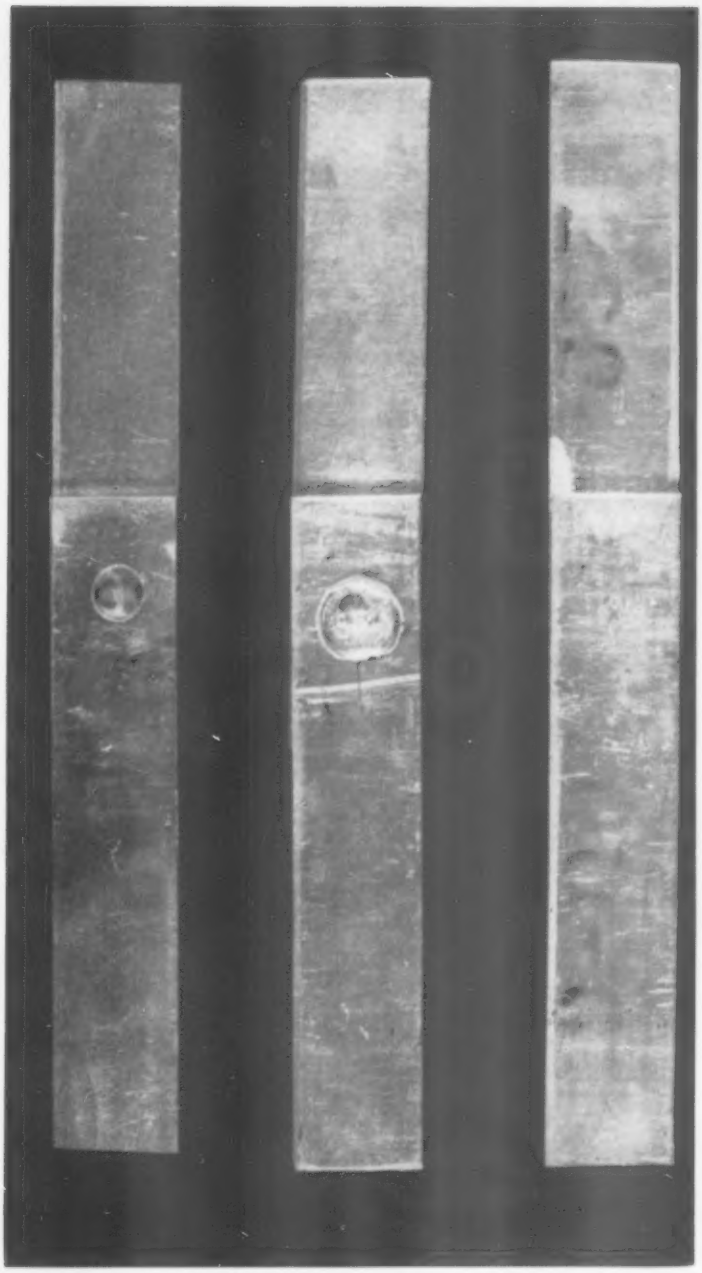
Table 4—Overlap CO_2 Welds with Gun on Top Sheet

Thickness combination, in. (Note 1)	*Minimum overlap and width, in.* 	*Tensile shear total load, lb (Note 2)*	*Arc welding current, constant potential welder, reverse polarity*	*Arc welding time, cycles (Note 3)*
0.064–0.064	1	1700	300	50
0.078	1	1700	300	50
0.125	1	2500	420	65
0.188	1	2800	420	65
0.250	1	3000	420	65
0.078–0.064	1	1500	300	50
0.078	1	1500	300	50
0.125	1	3400	420	65
0.188	1	4000	420	80
0.250	1	4000	420	90
0.125–0.064	1	2200	420	65
0.078	1	2300	420	65
0.125	1	2800	420	65
0.188	1	4300	420	80
0.250	1	4500	420	90
0.188–0.064	$1^1/_4$	2300	460	65
0.078	$1^1/_4$	2500	460	65
0.125	$1^1/_4$	3000	460	80
0.188	$1^1/_4$	4700	460	90

Note 1. In all cases the sheet size in combination with the other thickness is the sheet nearest the gun nozzle. For example: (a) thickness combination, 0.078 to 0.188, the 0.078 thickness is in contact with the gun nozzle.

Note 2. The above tensile shear values were obtained on test pieces having a width equal to the recommended minimum overlap.

Note 3. Gas flow in all combinations shown was 30 cfh CO_2 gas—welding grade.



[Fig. 17 Arc spot plug weld on two pieces ⅛-in. aluminum, showing [before and after welding comparisons

Fig. 18 ¼-in. fillet-weld, straight polarity—16 ipm

8. Plug and fillet, butt and corner tack welding techniques are greatly simplified. These type of welds by the flux-coated metal-arc process are quite difficult to make and frequently require backing mediums.

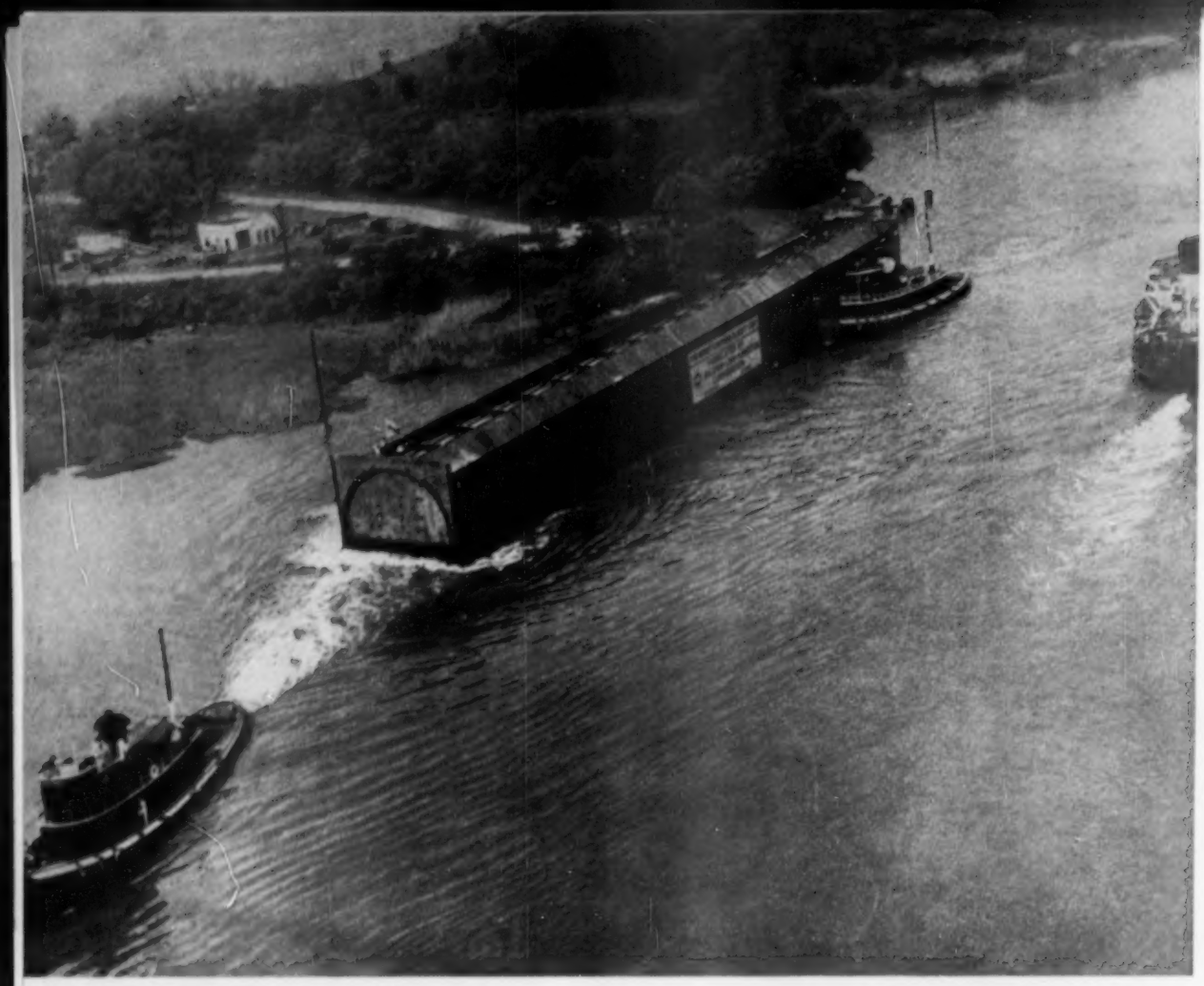
9. No special backing mediums are required for any type of inert arc-spot type of weld.

10. Mechanization is entirely feasible.

11. Low-cost equipment can replace very expensive resistance spot-welding equipment.

12. The equipment is readily portable and is self-contained with a power source, wire-drive control, gun, and water-cooling system as shown in lead photograph.

13. The equipment is versatile and can be used as a combination tacking medium for subassembly and for regular welding. Figure 18 represents a regular weld made with the portable equipment used as a welding tool and not for arc spot.



Towing tube through Delaware River

A NEW CONCEPT IN FABRICATION AND LAUNCHING OF VEHICULAR TUNNEL TUBES

BY F. P. IAPALUCCI, C. J. ASCENZI AND S. W. GEARHART

Proper planning of station time and tooling permits welding to continue practically uninterrupted, while fitting and assembling proceeds simultaneously

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SYNOPSIS. In building one of the largest, underwater, vehicular, trench-type tunnels in the world, a new concept in the design, fabrication, assembly and launching of tunnel tubes was employed. This paper will describe the fabrication methods, equipment, launching and final assembly of the tubes at the tunnel site.

Introduction

Over thirty-five years ago, a proposal was made for a railroad tunnel under Hampton Roads, Va. Today, this has developed into one of the world's largest trench-type tunnels for motor vehicles. In 1950, the Virginia General Assembly directed the State Highway Commission to construct a Bridge-Tunnel system to

replace the state-owned ferries. This was to eliminate time-consuming bottlenecks to motor travel between the two shores.

The Hampton Roads Bridge-Tunnel system, with twenty-three miles of connecting road work, will cost approximately $58,000,000.

Merritt-Chapman and Scott, Inc., general contractors for the Bridge-Tunnel project, awarded to the Baldwin-Lima-Hamilton Corp., Eddystone Division, the contract for the fabrication of 6863 ft of double-wall steel tunnel lining.

Preliminary work on the Bridge-Tunnel project included the construction of two portal islands, and the excavation of the tunnel trench on the river bottom between these islands. The north portal island, 1400 x 170 ft, was created by relocating a connecting channel. This island is 11 ft above the mean sea level. The south portal island, 1250 x 170 ft, was more complicated. An excavation 100 ft deep was required to remove unstable silt. Suitable sand was then pumped into the excavation from the harbor bottom to form this island. The two islands, by means of two open, low-level, concrete bridges, will link the tunnel with the northern shore at Old Point Comfort and the southern shore at Willoughby Spit, Va. These will provide a two-lane, 30-ft roadway.

The finished tunnel will have a two-lane, 23-ft roadway with a 14-ft ceiling clearance. At the deepest point the roadway will be 105 ft below the mean sea level.

The trench-type tunnel consists of 23 tubes, each 301 ft 10 in. long. These tubes are launched into the Delaware River, then towed to an outfitting site at Lamberts Point, Norfolk, Va., about five miles from the tunnel site. Here the final interior work, including the road bed is completed. The tubes are then towed to Hampton Roads, Va., the final tunnel site.

At this point, concrete is poured between the double wall of the tube, until the tube barely remains afloat, with approximately 2 to 3 ft of the tube above water. It is then towed and placed between two screeding tugs. These tugs are approximately 360 ft long and are joined by beams, so that they are permanently spaced to receive the tubes. The tugs are anchored to the river bottom at four points to maintain their exact position above the tunnel trench. The tube is drawn between these screeding tugs and is attached by cables and winches to the beams to permit the lowering of the tube into position (Fig. 1). The remaining concrete is now poured between the two walls and the tube is then lowered to the bottom of the channel. Employing the same procedure, the next tube is placed into position where divers, placing pins through lug holes, clamp and lock it to the preceding tube at the dam plate section. Next, semicircular connection plates, having half-sheet piling connectors, are driven into place. Concrete is then poured by the tremie method between the two tubes completely enclosing the joints or dam plate ends. When a number of the tubes have so been placed and joined, the dam plate circle between the tubes is then removed by flame cutting. This procedure is repeated until all 23 tubes have been joined together to form the underwater tunnel. The tunnel is then covered with sand to a minimum depth of 5 ft for protection against water currents and ships dragging their anchors against the tunnel.

The previous tubes manufactured by other companies were built on shipways, much in the manner of a ship. The bottom pieces were placed down first

Fig. 1 Positioning tube between screeding tugs prior to sinking

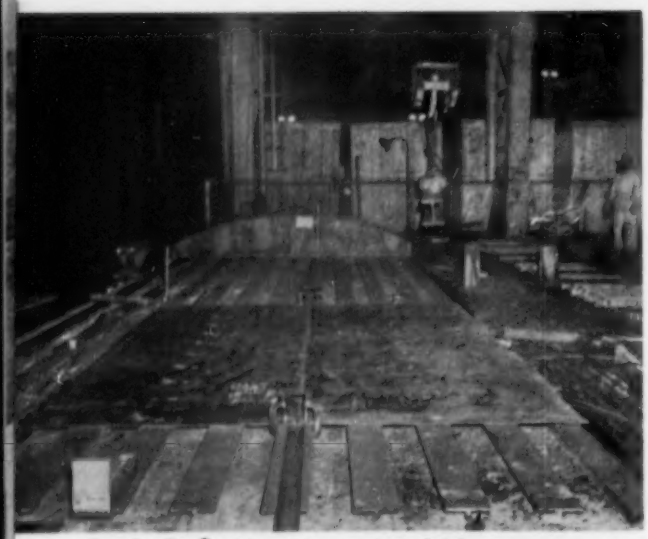


Fig. 2 Test weldment to measure shrinkage

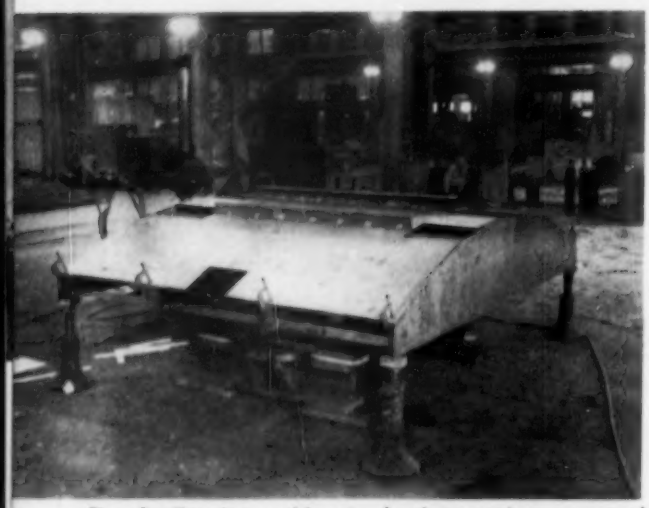


Fig. 3 Draping weldment—showing specimen removed for nondestructive and destructive testing

Fig. 4 Oxygen cutting 52-ft plate for inner-shell assembly

and the sides added later. This meant several areas of operation and much scaffolding and form work. Also, the tubes were launched endwise, thus requiring special stiffeners and handling.

After analyzing these methods, it was decided that new concepts of fabrication, assembly and launching were necessary in order to produce the tunnel tubes in a more efficient and economical manner. With these new concepts in mind, our engineering and manufacturing personnel engineered, designed and fabricated all of the assembly, welding and launching equipment required.

Materials and Specifications

The material requirements of the entire project conformed to ASTM A-373-54T and ASTM A-7, "Structural Steel for Welding."

The welding procedures and welders were qualified in accordance with the "American Welding Society Standard Specifications for Welded Highway and Railway Bridges (D2.0-47)" and the "ASME Boiler and Pressure Vessel Code, Section IX."

Prior to production, full scale weldments were made for each type of joint to evaluate physical properties, filler metals, shrinkage allowance, distortion and welding sequence (Figs. 2 and 3).

Assembly and Fabrication

The 6863-ft tunnel was designed to be fabricated as 23 separate tubes each 301 ft 10 in. long.

In order to reduce cost of both materials and fabrication, it was decided to build these tubes in 20 sections approximately 15 ft long.

Each section consisted of an outer-octagonal shaped wall 37 ft across the flats and an inner shell 33 ft in diameter. These are joined together by radial struts and stiffeners, with a diaphragm at one end.

Inner Shell and Longitudinal Stiffeners

The development of the inner shell required four

Fig. 5 Automatic submerged-arc welding two 52-ft inner-shell plates

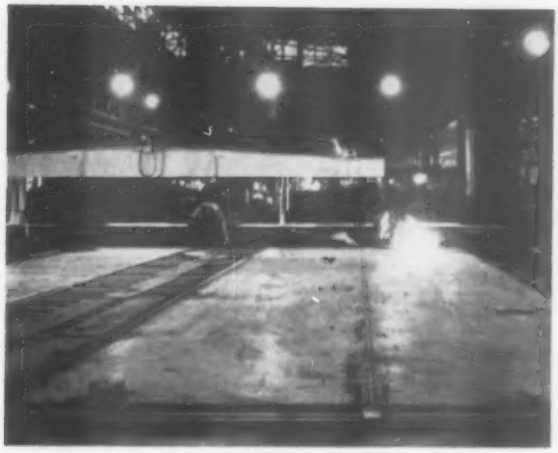


Fig. 6 Attaching draping lugs and handling of 52-ft plate with magnets

Fig. 7 Double-head automatic submerged-arc welding and positioning fixture for longitudinal stiffeners

Fig. 8 Closeup of automatic submerged-arc welding of longitudinal stiffeners

plates $^{5}/_{16}$ in. thick, 7 ft 6 in. $\pm$ $^{1}/_{32}$ in. wide and a length of 52 ft $\pm$ $^{1}/_{32}$ in.

In this operation two problems were involved: (1) the handling of plates of this size, and (2) distortion encountered in the flame-cutting operations. These problems were solved by designing and fabricating a special lifting device to handle the plates and act as a weight during the flame-cutting operation. This lifting device was made from heavy structural members and plates and had three magnets attached to the upper beam, properly spaced, for handling of the plates.

A special cutting table, with fixed machine tracks parallel to the lines of cutting and adjustable quick acting stops for proper location of the plates in relation to the cutting machines, was developed.

Portable cutting machines were used to oxygen cut the four sides simultaneously (Fig. 4). To develop the proper plate dimensions and joint geometry for welding, all the cutting torches and nozzles were locked with dowel pins. To compensate for the movement of the plates at the cutting area, all torches were roller mounted to maintain the correct distance between the plate and cutting nozzles.

Two of these plates are then welded at the next station with automatic submerged-arc welding, using a square butt joint. This makes one-half of the inner shell plate (Fig. 5).

Lugs are welded to the plates for handling and locking at the final assembly barrel fixture. At this point, the locations of the chairs and stirrups are spotted, with paint, through perforated paper templates. This eliminates the need for either expensive locating fixtures or layout time (Fig. 6). The background of Fig. 6 shows how the upper box beam of the oxygen cutting weight and handling device is detached to permit unloading and handling of plates prior to oxygen cutting operations.

The assembly is then turned over by means of special clamps and overhead cranes and moved to the next station. Here, the reverse or back side of the square-butt joint is automatic submerged-arc welded. The special track for the submerged-arc welder, also used as a weight, alternates between both welding stations. This permits welding to continue at one station, while handling and fitting at the other station. The assembly is then transferred to the next station by means of a winch and cable.

A traveling carriage was built incorporating a holding fixture and automatic submerged-arc welding heads. The holding fixture consisted of slotted holding blocks activated by hydraulic jacks, to align and force the stiffeners down to the inner shell plates (Fig. 7). A continuous horizontal fillet weld on both sides of the stiffeners is made simultaneously with automatic submerged-arc welding (Fig. 8). This fixture eliminates

time-consuming fitting, dogging, tacking and manual welding, and most important of all, distortion.

While applying the longitudinal stiffeners, a second plate assembly 15 x 52 ft is positioned for butt welding to the first assembly, making an inner-shell plate 15 ft wide x 104 ft long. The transverse butt weld is completed on the top side only, by manual metal-arc welding, using an adjustable copper backing bar. To complete the inner-shell plate, longitudinal stiffeners are now applied to the remainder of the assembly. The inner-shell plate is now ready for wrapping (Fig. 11).

In order to form the inner shell and assemble the diaphragm and form plates, the world's largest rotating, welding and assembly fixture was designed and built.

A large welded bull gear was mounted on one end of a fabricated box shaft 40 in. in depth and 36 ft long. This was powered by a pinion gear on the output shaft of a gear reduction unit. The input shaft of this reduction unit was connected to a 10-hp 1750-rpm motor, to provide a rotational speed of 10 fpm. At the other end of this shaft, there was welded a fabricated ring, built in four equal segments to allow collapsing and expanding for assembly purposes.

In addition to rotating the ring for assembly and welding purposes, this driving mechanism was designed with sufficient torque to pull the inner shell from the previous welding and assembly station, and wrap it around the outside of the ring. This was a new concept in the forming of shells of this magnitude.

The segmented rings were originally set to the proper diameter, and permanent stops were so located, that the ring could be expanded to the same diameter throughout the entire job. Each segment was designed for a $^1/_2$-in. travel by means of screws.

On the ring portion of the fixture, chain links were permanently located at predetermined points. This was necessary to accurately locate the longitudinal stiffeners radially on the fixture, and in proper relation to the diaphragm sections.

The chain links are attached to the first set of welded lugs on the inner-shell plate. Gage pins are located on the front face of the ring fixture to maintain proper alignment of the shell during wrapping. The positioner is then rotated to a predetermined point, approximately 90°, at which time, two sets of lugs on the inner shell are pinned to the ring. The plate is then completely wrapped and the remaining lugs on the shell plate are pinned.

The final transverse butt joint is now welded with manual shielded metal arc, as well as the back side of the first butt joint which had been partially welded on the assembly table. While the welding of the butt joints is being completed, the fixture is rotated to a fixed center line location. This establishes the correct relationship dimensionally between the inner shell assembly and the first diaphragm and form plate subassembly (Fig. 10).

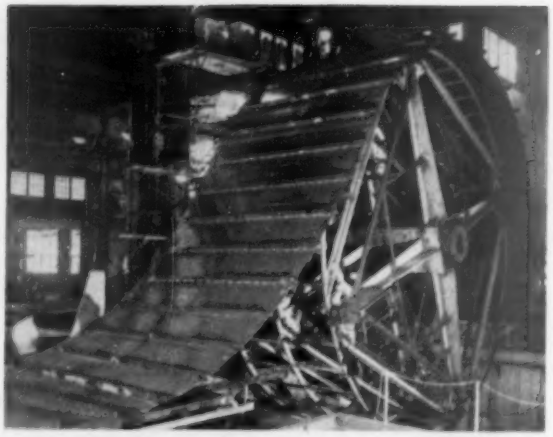


Fig. 9 Draping inner-shell plate and longitudinal stiffener assembly over ring fixture

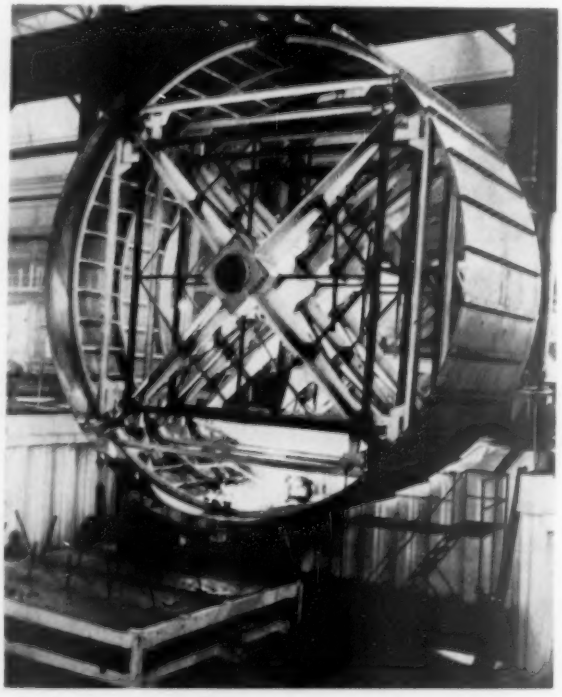


Fig. 10 Manual shielded metal-arc welding of transverse butt joint of inner shell and applying first diaphragm and form plate assembly to the shell

Diaphragm and Form Plate Subassemblies

The diaphragms were built in eight sections, to conserve steel and to facilitate handling and final assembly.

The diaphragm web plates, $^5/_{16}$ in. thick, were oxygen cut to size using multitorch carriage-type cutting equipment with electric eye tracing attachment (Fig. 11). The diaphragm, flange and stiffener plates were ordered to required width and sheared to length.

Rotating assembly and welding fixtures permitted rapid and easy assembly and positioning of parts for downhand welding.

The form plates were built in seven sections. Plates,

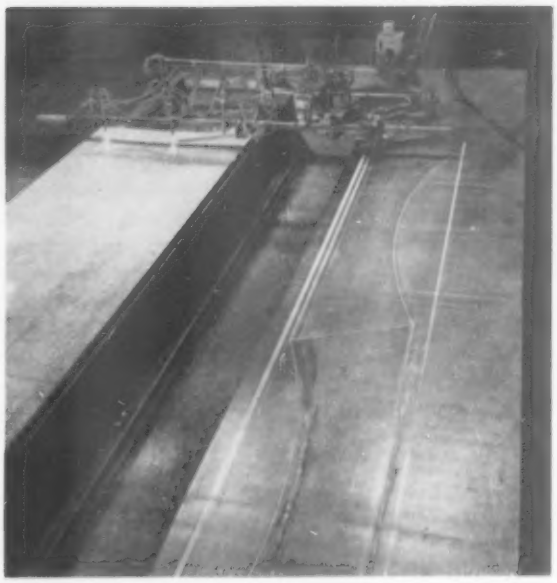


Fig. 11 Oxygen cutting diaphragm web plates

Fig. 12 Oxygen cutting form plates

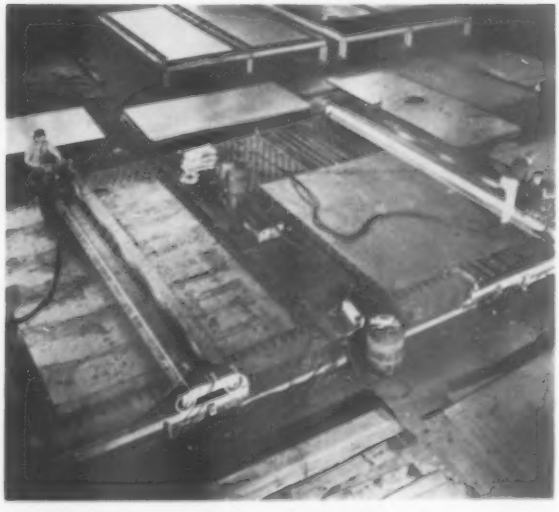


Fig. 13 Automatic submerged-arc welding of form plates

$\frac{1}{4}$ in. thick, of different lengths and widths, were oxygen cut simultaneously on three sides. Portable cutting machines on fixed tracks, with a floating torch and nozzle device, to maintain proper tip distance were used. Permanent points were established on the burning table for quick alignment of plates. These same points were also used in subsequent welding operations (Fig. 12).

In order to handle these plates with magnets and permit fast, economical loading and unloading at the welding station, a combination holding and welding carriage was built. Two parallel heavy H-beams were joined and mounted on wheels, one of these beams carried the automatic submerged-arc welding head. Rails on each side of the welding stations were hinged at one end and raised or lowered at the other end, by means of hydraulic jacks. This allowed the entire unit to move into or out of the welding position by means of gravity. When lowered into position, the heavy beams held the plates against a copper backing bar during welding operations (Fig. 13).

Radial angles, miscellaneous brackets and stiffeners were applied at the next station. Slotted aluminum channels with quick acting clamps were used to position and hold these during welding. The diaphragm subassemblies were then welded to the form plate subassembly. The completed form plate and diaphragm assembly is moved to the rotating ring fixture for application to the wrapped inner shell plate assembly.

One of the problems in assembling and welding a

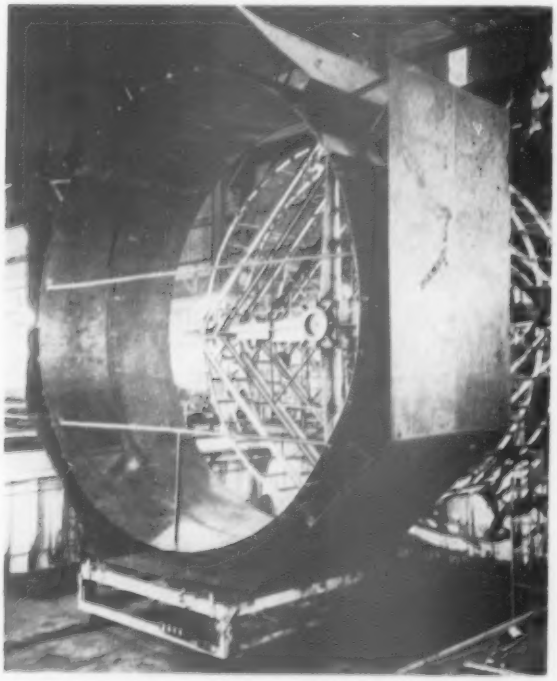


Fig. 14 Removing section from barrel "Ferris-wheel-type" fixture

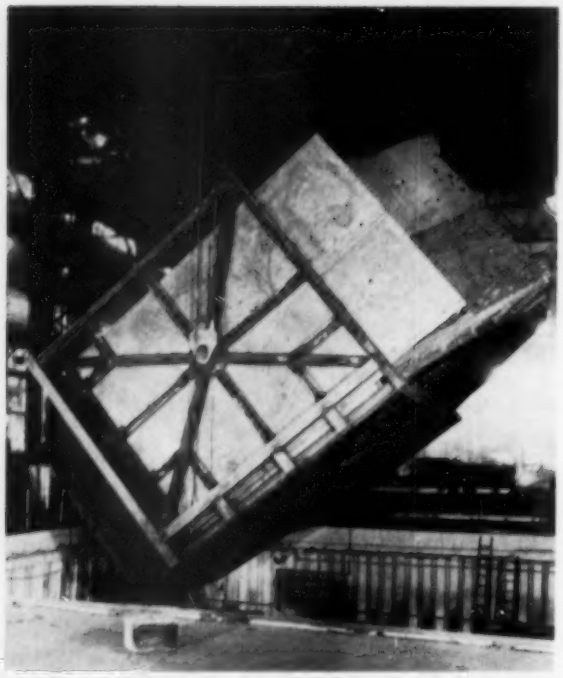


Fig. 15 *Transferring section from pit to trailer*

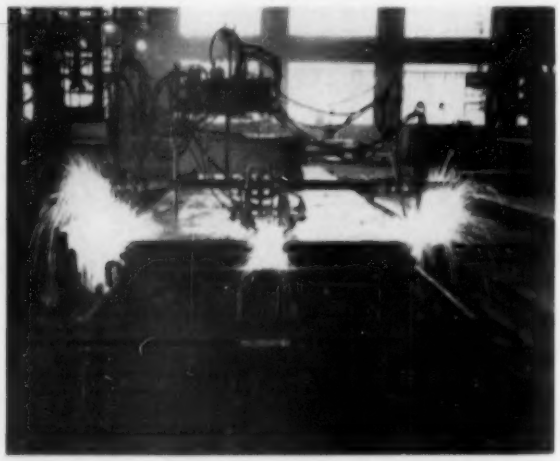


Fig. 16 Multitorch oxygen cutting of dam plates

typical section was clearance under our 35-ft high cranes. This required excavating a pit 10 ft deep and approximately 50 ft square. At the bottom of this pit, we installed a track and a special truck with a hydraulically operated platform for assembling and removing the section from the rotating fixture. The diaphragm and form plate subassembly is located on the platform, moved under the inner shell, and raised into position for tack welding. The rotating ring fixture is then indexed and the next subassembly is applied. This operation is repeated until all of the diaphragm and form plate assemblies are located and tack welded. All the welding is completed with the exception of the butt welds between the diaphragm web plates.

The section is removed from the rotating fixture by positioning the truck, raising the platform to take the load (25 tons), collapsing the ring, and then pulling the truck with the section to the end of the pit (Fig. 14).

The handling of a section of this size and weight, with relatively thin members, presented a difficult problem. In order to get the section out of the pit, and the shop, it was necessary to develop a sling or cradle to turn it on its side, and later at the dock, to turn it vertical again. This was a large frame-like device, with a pin at each side, designed to allow the section to cant 30 degrees where the auxiliary crane hook brings it to a horizontal position (Fig. 15).

It is then placed on a specially designed and fabricated trailer. Now, the welding of the diaphragm web plates is completed. Chairs and stirrups for the reinforcing rods are applied and welded to the inner shell. The section is then thoroughly inspected and transported approximately one mile to the final assembly and launching site.

Before continuing with the final operations at the dock site, the fabrication and welding of the dam plates will be described.

Fabrication of Dam Plates and Connection Plates

Dam plates, or water-tight bulk heads, weighing approximately fifty tons, are used to seal both ends of the tube for launching, towing and final assembly of the tube at Hampton Roads, Va. These dam plates are fabricated by oxygen cutting and beveling to size,

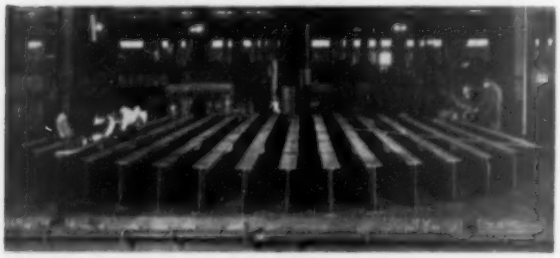


Fig. 17 Fitting and welding station for dam plates

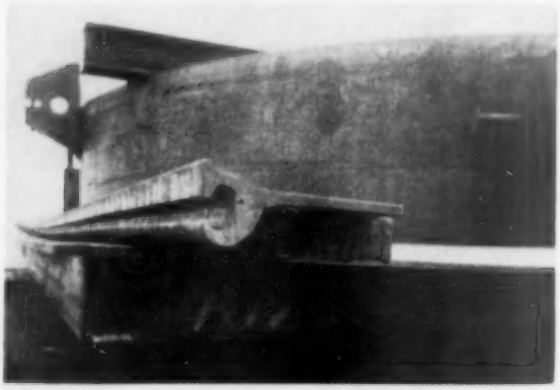


Fig. 18 Closeup of half-sheet pilings used for connecting tubes under water

five plates $^{9}/_{16}$ in. thick x 42 ft long, using multitorch equipment with an electric eye tracing attachment. The plates were made to vary in width so that the I-beams could be used as backing bars in automatic submerged-arc welding of the plates (Fig. 16).

These plates are then fitted together to form a 42 ft square. Oxygen-cut I-beams, of varying lengths, used as reinforcement of the dam plate, are then placed parallel to each other so that their ends form the periphery of a 33 ft diameter circle on the dam plate proper. Angles are located along the four edges of the dam plate (Fig. 17). These angles and I-beams are then fillet welded to the dam plate proper by automatic submerged-arc welding.

The dam plate is now turned over for application of flat bars, half sheet piling plates, collar and hood plates, miscellaneous brackets and stiffeners. Due to the size of this assembly, the previously described pit was used to secure necessary clearance under the crane hook.

After turning, it is set down again at the first fitting and welding station, where the flat bars and the butt joints of the dam plate proper are automatic submerged-arc welded. The half sheet piling plates, which is a special rolled section split by oxygen cutting to provide two plates, are manual shielded metal-arc welded to the flat bars (Fig. 18).

The assembly is then moved to a second station for application of collar plates, hood plates, etc. Here the parts are simultaneously positioned, welded, drilled and riveted. This is done to conserve space. All welding at this point is manual shielded metal arc.

The semicircular connection plates are fabricated by manual shielded metal-arc welding. Half sheet pilings are also welded to each side of the connection plates (Fig. 19).

The dam plates and connection plates are transported to the assembly ways on the same trailer used for transporting tube sections.

Final Assembly and Launching of Tubes

Up to this point, we have covered the fabrication of component parts of a tube in the shop. The final assembling, welding and launching at the dock site was another major problem.

Fig. 19 View of connection plate assembly used to seal joints between tubes underwater

As previously stated, many methods of final assembling and launching were investigated and discarded. It was finally decided to build the tubes on assembly ways, pull them over to the launching device and lower them into the water on a mechanical platform elevator. The assembly ways consisted of twenty sleds having triple surfaces, which supported the tube on the bottom and lower 45-degree form plates.

The fabricated section in the cradle, upon reaching

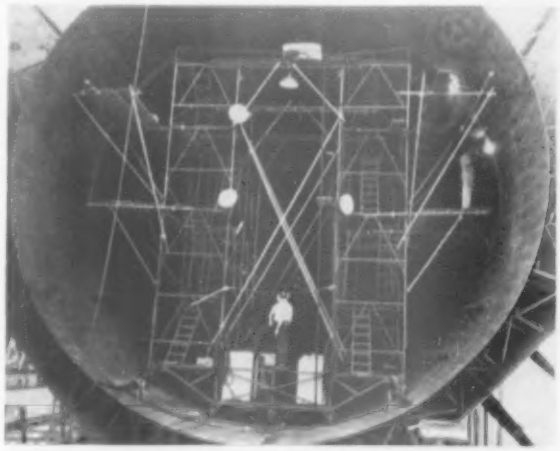


Fig. 20 Portable scaffold for welding and fitting operations inside of tube

Fig. 21 Applying north dam plate to first section of the tube

the assembly site, is removed from the trailer, turned to a vertical position, placed on the first sled of the assembly ways, and the cradle removed. As subsequent sections arrive, they are placed progressively on the assembly ways. Using hydraulic jacks and "come alongs," which are screw-operated turn buckles, the sections are pulled and butted together for welding.

To permit maximum welding in the most favorable position, backing strips are applied between the sections, on the bottom half of the outside surface of the inner shell and on the inside of the top half of the inner shell.

All welding at the final assembly ways was performed by the manual shielded metal-arc process.

To enable the workmen to perform all fitting and welding operations on the inside of the tube, a portable scaffold, mounted on rollers, containing the welding and oxygen cutting equipment, was installed. In addition, this scaffold was used for installation of conduit (Fig. 20).

As the tube assembly progresses, the north dam plate is installed and welded to the first section of the tube (Fig. 21).

A second portable scaffold, containing all necessary welding and oxygen cutting equipment, was installed on the outside of the tube. This enabled the workmen to perform all fitting and welding operations in this area. It was completely enclosed to protect the operators and equipment from the elements (Fig. 22).

When the final section is installed and welded, the entire tube and fixture assembly is then moved sideways to the launching platform. The movement of the assembly fixture, with the tube in place, is performed by drawing the sleds across steel plates imbedded in concrete. This was done with the same cables and winches used in the final launching (Fig. 23).

At this point in the fabrication, there are 20 sections and one dam plate assembly to make the tube. The next step is to wire the reinforcing rods to the stirrups and chairs previously welded in the shop. Miscellaneous brackets, towing lugs and other accessories are also welded in place. A third scaffold, mounted on a commercial truck driven through the tube, was used for these operations.

Finally, the south dam plate is fitted and welded. The tube is now ballasted by pouring 1600 tons (800 yards) of concrete between the outer form plate and the inner shell plate, filling this area to a depth of about 7 ft. The concrete must be vibrated continually during the pouring operation, to prevent formation of air pockets. After the concrete has set for twenty-four hours, the tube is launched at high tide, by means of mechanical platforms on launching ways built in our shops.

Twenty fabricated beams, 75 ft long and 48 in. deep, were set flush with the top of a concrete bulkhead

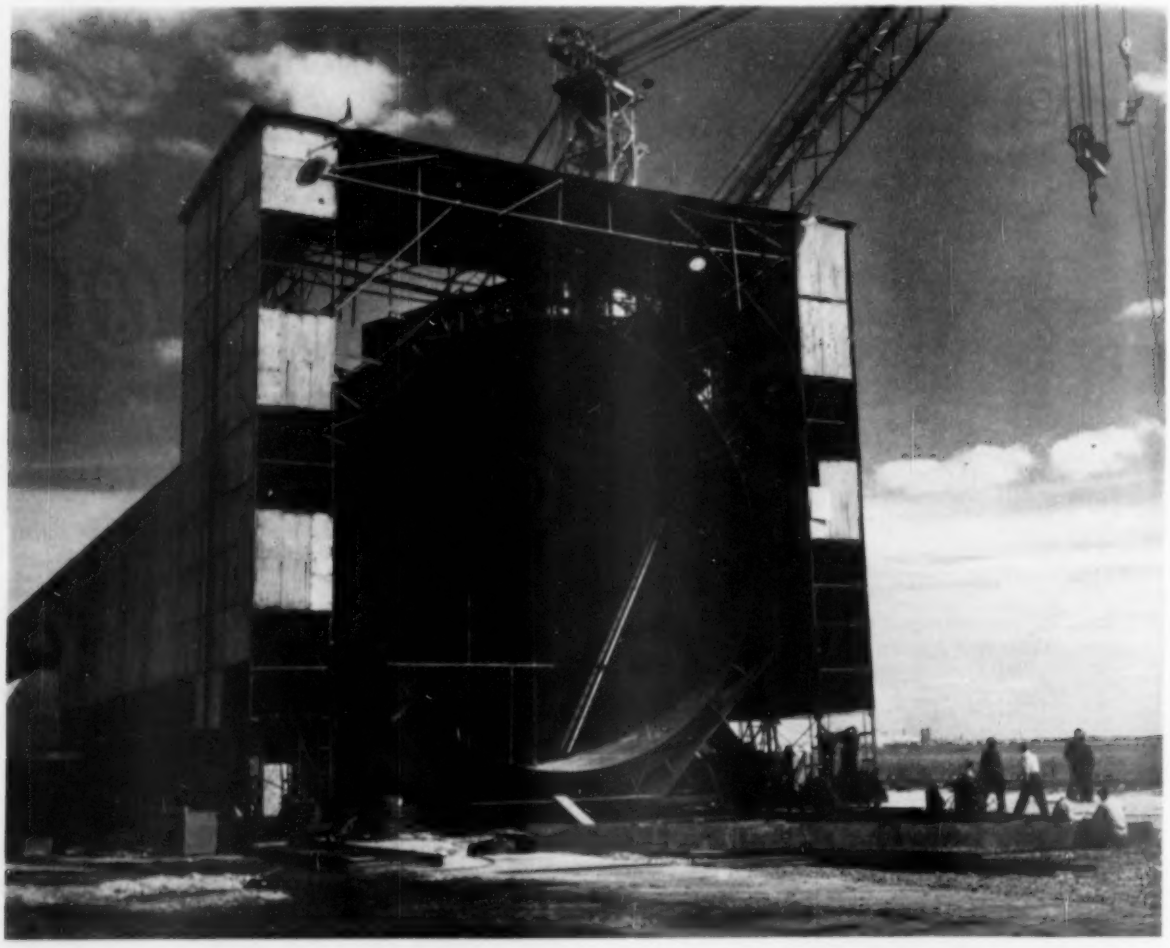


Fig. 22 Portable scaffold for fitting and welding of outside of tube

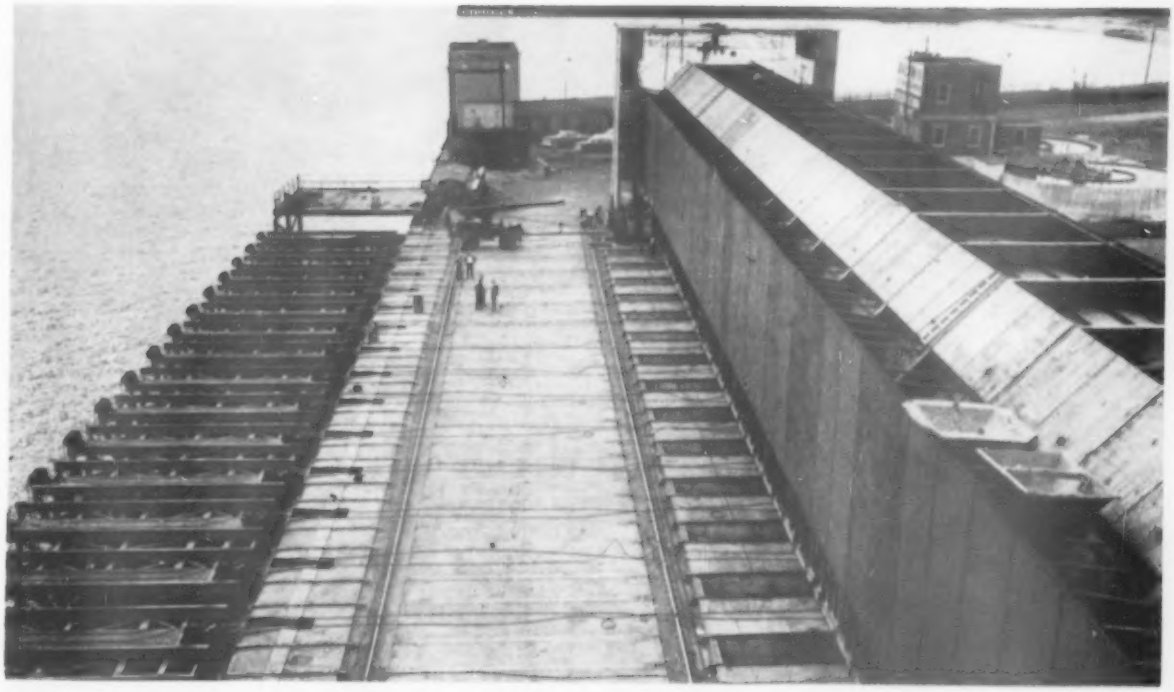


Fig. 23 View showing tube ready for transfer to launching platform

which was approximately five feet above mean high water. These beams extended out into the water at an angle thirty degrees below horizontal, and were supported on steel piling driven to the river bed. At the upper end of each beam and below the top surface, a grooved, fabricated cable drum 20 in. in diameter and 10 ft long was supported by end bearings. A fabricated bull gear was then flange mounted on the center of the cable drum and meshed with a pinion gear. The pinion gear was connected to the output shaft of a commercial gear reduction unit of 66,000 in-lb torque capacity. The input shaft of this unit was connected by sprockets and a chain to a 2-hp 1150-rpm motor (20 required). A "synchrotie" unit (20 required) was then attached directly to the shaft of each 2-hp motor to provide a balanced load over all 20 motors during the launching operation. This was controlled from a major panel—each unit having an individual starter and also able to operate in multiples.

Ten fabricated triangular platforms were mounted to the top surface of the beams, which allowed the top surface to be horizontal at all times. The two ends of a continuous 1 1/8 in. diameter wire cable, 680 ft long, was attached by suitable clamps to each end of the cable drums. The cable was then reeved to a pulley at the bottom end of the platform and back to a pulley mounted on the upper end of the beam, then back to another pulley on the same shaft as the first pulley, then up to a pulley on the top end of the platform and back to an equalizing pulley which was attached to the concrete bulkhead.

A total speed reduction of 5700 to 1, from the synchronous motors to the cable drum, allows the wire cable to unwind at approximately 12 ipm. The four-part reeving of the cables over the pulleys allows the platforms to slide down the beams at a rate of 3 ipm. When the tube attains buoyancy (10-ft draft) and is towed away, the motors are reversed and the platforms returned to their original position ready for the next launching (Fig. 24).

Fig. 24 Tube buoyant in water, ready for towing

Inspection

In addition to the required qualification of welders, they were instructed in the use of AWS E6024 electrodes. They were also required to pass the ASME type fillet-weld test with this electrode.

All butt welds of the inner shell and the dam plates

were inspected by selective trepanning, vacuum soap bubble testing and spot radiographic examination. All other welding, which was primarily fillets, was inspected by visual means only, for appearance. Weld gages were used for checking size and reinforcement.

The dimensional tolerances of the tubes were as follows:

Outside diameter of the inner shell (section)	33 ft ± 1/8 in.
Outside diameter of the inner shell (tube)	33 ft ± 3/8 in.
Length of each tube	301 ft 10 in. ± 1/4 in.
Length of 23 tubes	6863 ft 0 in. ± 1/2 in.

In addition to the dimensional tolerances shown above, other interesting facts concerning this project are listed below.

Length of tube (composed of 20 fabricated sections and 2 dam plates)	301 ft 10 in.
Diameter—inner shell	33 ft 0 in.
Outside outer octagonal form	37 ft 0 in.
Weight of steel	1,140,000 lb
Weight of reinforcing rod	86,000 lb
Weight of dam plates (82,400 lb each) 2 required	164,800 lb
Weight of conduit	8,000 lb
Weight of keel concrete	3,200,000 lb (800 cu yd)
Total weight for one tube	4,598,800 lb (2299 tons)
Total weight—steel for 23 tubes	32,172,400 lb (16,086 tons)
Total weight—steel and concrete for 23 tubes	105,772,400 lb (52,886 tons)

Method of launching—gravity on 30 "deg" ways (controlled by 20 synchronous motors (2 hp) and 1 1/8 in. diam wire cables)
Launching time—1 1/2 hr (2 men); average tube draft—10 ft
Horsepower required in tugs (2) for towing—1000
Average travel time to Hampton Roads, Va. = 52 hr
Route to Hampton Roads, Va.—Delaware River to Delaware & Chesapeake Canal to Chesapeake Bay to Hampton Roads, Va.

Total feet of welding (1) section	2500 ft
Total feet of welding (1) tube	50,000 ft (10 miles)
Total feet of welding 23 tubes	1,150,000 ft (230 miles—New York City to Washington, D. C.)
Total pounds of electrodes (1) section	720
Total pounds of electrodes (1) tube	14,390
Total pounds of electrodes 23 tubes	330,000 (165 tons)
Total pounds of flux (1) section	115
Total pounds flux (1) tube	2,300
Total pounds flux 23 tubes	52,900
Total feet oxygen cutting (1) section	1600 ft
Total feet oxygen cutting (1) tube	32,000 ft (6 miles)
Total feet oxygen cutting 23 tubes	736,000 ft (138 miles—Philadelphia to Washington, D. C.)

Conclusion

In this paper, no attempt has been made to detail specific technical information for base metal and welding procedures. Required tests under the applicable specifications plus proper selection of welding procedures, qualified welders, adequate supervision and inspection produced good welding results with practically no repairs. As an example; in over 300,000 ft of welding butt joints between the dam plates and inner shell plates, less than 100 ft of welding had to be repaired.

The authors have endeavored to show that weldments of this magnitude can be produced more economically and easily, by proper planning of station time and tooling to permit welding to continue practically uninterrupted, while fitting and assembling proceed simultaneously. The processing and flow of material, with the allied problems of proper tooling and fixtures, have been stressed.

In the authors' opinion, the welding industry is not limited by size in planning production of weldments on an assembly-line basis.

Acknowledgments

The writers wish to express their sincere gratitude to Mr. J. J. Rosecky, vice-president, Baldwin-Lima-Hamilton Corp., Eddystone Division, for his guidance and interest in planning and executing this project; also, to the Messrs. R. Willi, D. Prete, A. Dunn and J. R. Brown, Jr., members of our engineering and manufacturing staffs.

Appreciation is also extended to Mr. J. J. Chyle, Director of Welding Research, and his staff, A. O. Smith Corp.; to Mr. T. Berg, president, Arcway Equipment Co.; and to members of the Air Reduction Sales Co. and Linde Air Products Co. for their efforts and contributions in the planning of this project.

90,600?

Yes . . . in a 12-month period from July 1955 to June 1956, 90,600 reprints of vital articles in The Welding Journal were requested . . . proof of the authoritative editorial calibre of The Welding Journal. Proof, too, of the acceptance by the welding and allied industries of The Welding Journal's high standard of reporting.

Fig. 1 Manual cutting of $^1/_2$-in. aluminum plate using conventional heavy duty gas-shielded metal-arc welding equipment

THERMAL CUTTING OF ALUMINUM, STAINLESS STEELS, AND HIGH-NICKEL ALLOYS

Recently developed gas-shielded metal-arc process permits the cutting of numerous materials which cannot be readily severed by oxygen cutting

BY EDWARD H. ROPER

SUMMARY. Using standard gas-shielded metal-arc welding apparatus, a process* has been developed which permits the cutting of numerous materials that resist oxygen cutting to such a degree that most of the severing of them is generally carried on by mechanical means. This new cutting process is capable of both manual and machine operation and produces cut surfaces which in many cases are suitable in the as-cut condition for further processing, such as welding. The necessary apparatus is likely to be available in any well-equipped shop doing fabrication of nonferrous materials, and the art is readily mastered by men trained in the field of gas-shielded arc welding or oxygen cutting.

Edward H. Roper is Manager, Technical Market Development, Air Reduction Sales Co., New York, N. Y.

Presented at 1956 AWS National Spring Meeting in Buffalo, N. Y., May 7–11.

* The cutting process covered in this paper is the subject of pending patent applications.

Background and Earlier Work

Ever since the oxygen-cutting process first proved capable of severing mild-steel sections without mechanical force, researchers have tried to adapt it to the cutting of other metals. Unfortunately, among the common metals of construction only mild steel appears to have the precise combination of physical and thermic properties which permit the oxygen jet to pierce and sever by oxidation alone.[1] Adding other materials to the oxygen jet, such as fluxes or combustible materials, permits the oxygen severing of numerous other metals, but the associated problems are such that these techniques are generally used only in the oxygen cutting of stainless steels.

The heat of the arc will also accomplish the severing of all metals used in common structural practice, but the action is purely a melting one. Such is the function of the arc in the common methods of carbon-arc, arc-gas and covered-electrode cutting.

The production of stainless steel in the United States has grown to the point where it reached 670,000 tons

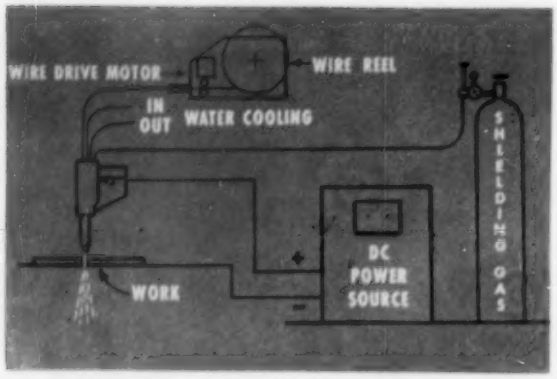


Fig. 2 Schematic diagram of gas-shielded metal-arc cutting equipment

Fig. 3 Machine cutting setup mounted on a standard travel carriage geared for high cutting speeds

last year while aluminum production reached 1,600,000 tons yearly at the same time. It is this sort of growth that has so greatly expanded the use of gas-shielded arc-welding methods in the past decade and provides such a fertile field for application of any method of cutting comparable in effectiveness to the oxygen cutting of mild steel.

Hull[2] reported use of the gas-shielded consumable-electrode method for cutting purposes. He also reported cutting with the nonconsuming arc, using it much in the manner of conventional carbon-arc cutting equipment.

Previously, another English author, Warren,[3] reported work done by the British Admiralty on cutting using consumable electrode wires in a gas shield. He disclosed a mild-steel electrode wire (Hull mentions aluminum) and noted by means of high-speed motion pictures that operation under conditions so adjusted that the wire extended clear through the cut was essential to best results. He also noted that, under these circumstances, the wire assumed a taper through the cut with the arc emanating from the side of the wire to the advancing face of the cut.

In this country Babcock's paper[4] confirms the English observations and describes the conditions for the cutting of a wide variety of materials.

Our own work has been directed toward the development of a commercially useful process that could be practiced with standard welding equipment likely to be available in a nonferrous fabricating shop.

Process Fundamentals

Equipment

The apparatus and its arrangement (Fig. 2) look schematically almost like a setup for welding. The differences are in power supply, wire cooling and shielding gases.

In Fig. 1 the operator is about to start a cut using conventional gas-shielded metal-arc manual welding equipment. In Fig. 3 there is depicted a machine cutting setup consisting of a standard filler wire feeder and the barrel of an automatic head normally used for gas-shielded arc welding. The travel carriage used in this picture is a standard one used for oxygen cutting geared to enable it to reach the necessary travel speeds.

As will be seen from the operating conditions to be described later, higher than normal currents are employed. Since a single power source large enough to supply the necessary current probably may not be found in the average shop, several units may need to be paralleled. This is done in the same manner as paralleling units for heavy welding.

We have found a variety of sources of d-c reverse polarity satisfactory. Rectifiers and motor-generator sets, both drooping and constant potential types, have been employed with equal success. Since the currents used are high, leads of ample capacity and good tight connections are essential. Some drooping characteristic machines tend to drop off in output under heavy loads, so this must be watched and compensations made. We have also found that power sources do not always put out the current indicated by the controls, so adequate meters to set the conditions are essential.

Warren[3] cited the use of ac with a superimposed high-frequency spark, but noted that the speed of cutting was about one-half that as when using the equivalent energy in dc.

Since the wire is fed at relatively high speeds, its physical condition is important. Its chemistry is not critical, but if there is anything about the wire or the wire handling, feeding, conveying or the current pickup part of the apparatus that interferes with uniform rate of wire delivery to the arc, then erratic cutting will result. Generally, these conditions can be checked by letting the wire feed from the gun with the current off and with the wire sliding through the hand, feeling for any unsteadiness in the feed.

Normally, mild-steel wire is used for considerations of cost, ease of feeding, and more efficient cutting. Where circumstances warrant, aluminum wire is used to cut aluminum, but these uses are rare.

The currents normal for this process are higher than customary for manual and some semiautomatic welding equipment. Water-cooled equipment and adequate water flow are important. The heating will be almost entirely of the I^2R variety, since the gun does not re-

Table 1—Typical Operating Conditions

Material	Thickness, in.	Current, amp	Wire size, in.	Wire type	Wire feed, ipm	Gas flow	Gas	Cutting speed, in.	Remarks
Aluminum	1/8	360	1/16	Mild steel	267	10	Argon	96	Machine cutting
	1/4	830	3/32	Mild steel	360	20	Argon + 1% oxygen	75	Manual cutting,
	1/4	880	3/32	Mild steel	370	20	Argon + 1% oxygen	144	Machine cutting
	1/4	880	3/32	Mild steel	355	20	Argon + 1% oxygen	100	Machine cutting, 30-deg bevel
	3/8	900	3/32	Mild steel	380	20	Argon + 1% oxygen	93	Machine cutting
	3/8	1200	3/32	Mild steel	500	20	Argon + 1% oxygen	125	Machine cutting
	1/2	850	3/32	Mild steel	390	20	Argon + 1% oxygen	56	Manual cutting
	1/2	900	3/32	Mild steel	380	20	Argon + 1% oxygen	72	Machine cutting
	1/2	940	3/32	Mild steel	440	20	Argon + 1% oxygen	46	Machine cutting, 30-deg bevel
	3/4	1200	3/32	Mild steel	475	20	Argon + 1% oxygen	47	Machine cutting
	1	1600	3/32	Mild steel	880	20	Argon + 1% oxygen	40	Machine cutting
Stainless steel and Monel	1/4	1320	3/32	Mild steel	540	25	Argon + 20% oxygen	85	Machine cutting
	3/8	1320	3/32	Mild steel	540	25	Argon + 20% oxygen	50	Machine cutting
	1/2	1200	3/32	Mild steel	580	25	Argon + 20% oxygen	35	Machine cutting
	1	1320	3/32	Mild steel	600	25	Argon + 20% oxygen	27	Machine cutting
C.P. nickel	1/2	1700	3/32	Mild steel	950	20	Argon + 20% oxygen	48	Machine cutting, 35-deg bevel

NOTE: Ordinarily the arc voltages put out by single control welding units are suitable, but if constant potential sets are used, the best voltage may have to be determined experimentally for each equipment arrangement. As a guide, these starting points are suggested: 1/8-in. aluminum—21 v, 3/8-in. aluminum—29 v, 1/2-in. stainless steel—33 v, 1/2-in. nickel—33 v.

ceive much radiation from the molten metal, the "puddle" being almost entirely in the kerf. The cutting proceeds very rapidly and under normal usage the work factor will be low, but if long cuts are made or the work factor otherwise is high, the temperature rise in various parts of the equipment should be watched.

Flow of shielding gases is not critical, but since mixed gases generally give the best result, either premixed gases or proportioners are required.

A wide variety of gases have been tried, such as air, oxygen, pure nitrogen, nitrogen with oxygen additions, carbon dioxide, helium, pure argon, and argon with oxygen additions. Only helium and argon (alone or with added oxygen) seem to give cuts of acceptable quality, with argon generally giving the best quality of cut surface. Carbon dioxide will give higher speeds as will nitrogen with oxygen addition, but the resulting surfaces would be acceptable only for the crudest scrapping operations.

Within wide limits of gas flow rates equally satisfactory results can be achieved, giving rise to the conclusion that the gas flow need only be enough to provide a gas shield under the prevailing circumstances of draft. Under normal circumstances we have found about 15 to 25 cfh satisfactory. In very still air this could be substantially decreased. Raising the flow as high as 100 cfh produced no noticeable benefits.

Operating Conditions

A wide variety of operating conditions will produce some sort of cut. In fact, with enough current and a high enough wire feed to handle it, the operator "can't miss." But if he is to produce cut surfaces that compare with the oxygen-cut surfaces of mild steel, the conditions given in the attached Table 1 should be used as a guide.

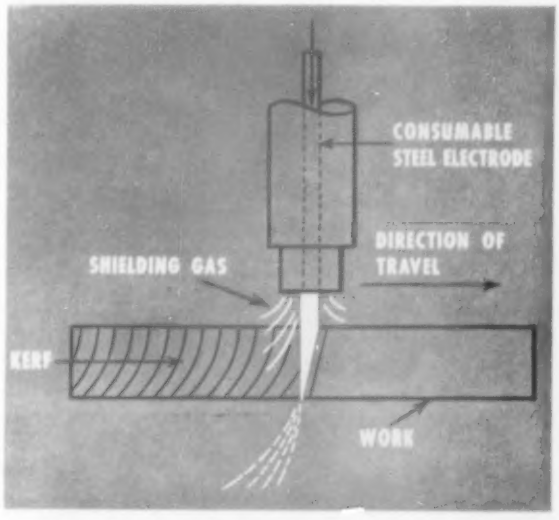


Fig. 4 Schematic detail of gas-shielded metal-arc cutting process. View at right angles to work

In general, variations between various aluminum alloys are not noticeable in hand cutting, but for machine cutting some variations in the relations between plate thickness, wire size, wire feed, and current and speed may be required to produce the highest quality of cut.

Operating Techniques

Schematically, the best conditions at the point of cutting are illustrated in Fig. 4. The operator must adjust the factors involved so that the wire melts in a tapered fashion with the arc going from the side of the taper in the direction of cutting and the tip of the

Fig. 5 Illustrating correct cutting conditions. The wire assumes a tapered shape with the end just protruding from the bottom of the plate

Fig. 6 The process produces shape edges and smooth cuts, as shown by the left-hand surface and slot in the center. The ragged cut on the front edge of this 1-in. thick Monel plate was produced by a cutting-type electrode

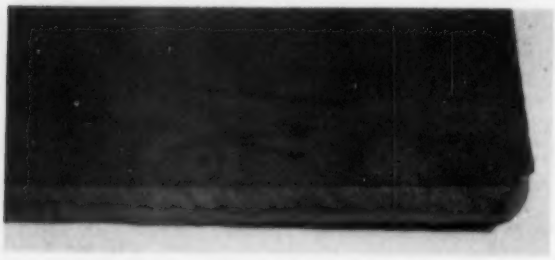


Fig. 7 Illustrating surface condition resulting from gas-shielded metal-arc cutting of $^1/_4$-in Monel plate

tapered section of the wire just protruding from the bottom of the plate. The correct conditions are shown in Fig. 5 which shows the wire just entering the kerf. The tapered shape of the wire and the width of the kerf are shown. It is easy to understand from this photograph why, under conditions of good operation, there is little chance of contamination of the base material by the electrode wire.

Manual cutting is easily accomplished once the operator has trained himself to keep the nozzle close to the plate ($^1/_2$ to $^5/_8$ in. away) and to move fast enough. Those skilled in the art of oxygen cutting will soon recognize the conditions of slag emergence and sound which indicate that a good cut is being made. Once one has noticed that "steady sputtering hissing sound" of good oxygen cutting also applies to arc cutting, he can tell if a good cut is being made even with his back turned.

Slag adherence may give trouble. Proper cutting conditions and positioning of the ground take care of this.

Safety Considerations

As in any industrial process employing high temperatures, certain normal precautions should be observed. We are dealing with an arc which radiates energy. This arc also is converting metal into vapors. In addition, the force of the arc strips molten metal from the end of the wire and additional metal from the kerf walls and throws this from the bottom of the kerf with considerable velocity. If cutting is done with the plate vertical, the slag will be ejected almost as forcibly in a horizontal direction as if an oxygen cutting torch were being used on mild steel.

Hence, the operator must be protected and fire prevention measures taken. The ventilation and other protective measures set forth in "Safety in Electric and Gas Welding and Cutting Operations," American Standards Association Pamphlet Z49.1–50 and "Recommended Safe Practices for Inert-Gas Metal-Arc Welding," American Welding Society pamphlet A6.1–55T should be observed.

Condition of the Cut Edge

The physical and metallurgical condition of the cut surface and the areas immediately adjacent are of great interest to those who would use any thermal cutting method. Of first interest is the smoothness of the cut surface.

The normal kerf is almost parallel sided, being slightly wider at the bottom. Sharp edges can be achieved as shown by the surface to the left and the slot in the center of Fig. 6. The surface on the front

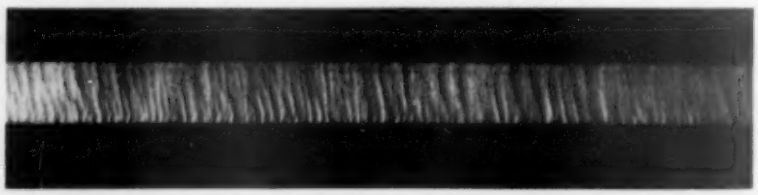


Fig. 8 Typical edge condition on a cut made on $^1/_2$-in. aluminum plate by the gas-shielded metal-arc cutting process. The cut is clean and square with shallow serrations

Table 2—Average Requirements to Make a Cut One Foot Long

Base metal	Power, kwh	Gas, cf	Wire, lb	Time, sec.
1/8-in. aluminum	0.03	0.03	0.06	5
1/4-in. aluminum	0.06	0.06	0.13	10
3/8-in. aluminum	0.17	0.09	0.25	15
1/8-in. stainless steel	0.08	0.06	0.17	9
1/4-in. stainless steel	0.20	0.14	0.41	21
3/8-in. stainless steel	0.24	0.15	0.44	22

edge of this piece of 1-in. thick Monel was cut by a cutting-type electrode. In general, excellent sharp edges and relatively smooth cuts are made by gas-shielded metal-arc cutting in stainless, Monel, copper and similar alloys. Fig. 7 is the cut surface of a piece of 1/4-in. thick Monel. In aluminum the edges are equally sharp, but the "drag lines" may be more pronounced as in Fig. 8. Unfortunately, our industry has yet to develop any mathematical standards for thermally or thermochemically cut surfaces, so what constitutes a "quality cut" is largely a matter of opinion. It can be said that surfaces of cuts made by gas-shielded metal-arc cutting are of such a quality that many people do not hesitate to weld on them in the as-cut condition. Where cleanup is required, as is generally the case with stainless steels, the amount of grinding that must be done is substantially less than when cutting is performed by some variation of the oxyacetylene cutting process.

The chemistry and microstructure of the cut surface have been the subject of some testing. Warren[3] reports the examination of cut sections through 1/8-, 1/4-, and 1/2-in. aluminum which showed the heat-affected zone never to exceed 0.005 in. He also made welds on edges thermally cut using iron-wire electrode and on edges which had been band-sawn, being careful to duplicate welding conditions. He could find no measurable iron pickup. Babcock[4] found the depth of the heat-affected zones in 1/4-in. material to range from 0.001 in. in aluminum to 0.005 in. in copper-silicon alloy. Chemical analysis of an aluminum plate with 0.44% iron showed 0.50% iron on the cut surface. This alloy with 0.10% iron showed 0.13% on the cut surface. When he made welds on cut surfaces of aluminum and analyzed the base metal, wire and weld metal, he reached the conclusion that the amount of iron pickup is so low as to have little or no effect on the weld deposit. Certain private communications reaching us from investigators whose research is not far enough along to publish indicates that the heat affected zone in certain precipitation hardening aluminum alloys may contain shallow intergranular cracks. It is hoped that the results of these studies may be published in the near future and that a comparison can be made with the cracking which occurs when the edges have been mechanically prepared.

Costs

It is always poor practice to put generalized cost data in a technical article, since such data are meaningless as applied to a specific shop. In Table 2 are given times and quantities of materials to perform one foot of cutting in certain materials. The reader can apply his own costs to these and draw his own conclusions.

Scope of the Process

The records indicate that successful cuts have been made in all the common aluminum alloys and a wide variety of chromium and chromium-nickel steels. Copper, copper-nickel alloys, and brasses have been cut as have some cobalt-chromium-tungsten alloys. Magnesium and titanium have been severed. There seems to be good reason to believe that this process can be applied to all the common structural materials, but whether it is the most economical method will have to be proved. For example, oxygen cutting is far superior for the cutting of steel and some aluminum alloys are soft enough to be very amenable to mechanical methods. It is believed that this new process will find its widest application in the heavier sections of the stronger aluminum alloys and in the stainless steels whose strength makes mechanical severing slow and whose oxidation resistance makes oxygen cutting difficult.

The power requirements give some indications as to the practical limits of thickness. Above one inch equipment not currently standard will be required unless the user is satisfied with a rough severing cut of short duration. Under such circumstances 1 3/4 to 2 in. is the present limitation.

Future Work

Although gas-shielded arc cutting is already in growing commercial use, there are possibilities for further experimental and research work. For example, we need to know more about the metallurgy of the cut surfaces and how they compare to mechanically prepared surfaces. Smoother cuts are needed for some applications. From observations of the arc it is apparent that there is an ideal wire diameter for each thickness range, and while 3/32-in. wire is ideal for thicknesses from 1/4 to 3/4 in., other sizes may be best for lesser and greater plate thicknesses. These are a few of the avenues to be explored.

Acknowledgments

The author wishes to thank Messrs. Edward Adams and Ivar Steen who developed the data and operating techniques described in this paper.

References

1. Slottman, G. V. and Roper, E. H., *Oxygen Cutting*, McGraw-Hill Book Co., pp. 13–17 (1951).
2. W. G. Hull, "Use of Gas-Shielded Arc Processes for Cutting Nonferrous Metals," *Welding and Metal Fabrication* (May, 1954).
3. W. G. Warren, "Electric Arc Cutting of Aluminum," *Ibid.* (March 1953).
4. R. S. Babcock, "Inert-Gas Metal-Arc Cutting," THE WELDING JOURNAL, 34 (4), (309-315, 1955).

SEE DISCUSSION ON NEXT PAGE

DISCUSSION BY JULIUS C. RITTER

1. We have equipment of this type at Boston Naval Shipyard.

2. Mr. Roper states that argon with 1% oxygen added gives best results. We have used both straight argon and argon + 1% oxygen and can see no difference in quality of cut.

3. I think that the arc current and cutting speeds shown in Table 1 are too high for $^1/_4$-in. aluminum plate. Although we know that you can cut at these speeds, there are times, especially in hand cutting, when it is better to cut at lower speed. For example, the table shows cutting speeds for $^1/_4$-in. plate of 75 to 144 ipm. We have made quality cuts at 30 ipm. For aluminum plates $^1/_2$ in. and over, I think the arc currents and cutting speeds are too low. For instance, the table shows $^3/_4$-in. plate cut at 47 ipm with 1200 amperes. We cut $^3/_4$-in plate at 65 ipm with 1450 amperes.

4. In reference to the condition of the cut edge. With handheld guns where the speed of cutting cannot be controlled accurately we have found the condition Mr. Roper mentioned. However, with automatic equipment used to cut $^1/_2$-in 618 plate in the T6 condition we could find no heat-affected zone, no oxide layer and no cracks. We could find no softening of the cut edge below specification allowance even when readings were taken within 0.005 in. of the cut edge.

5. Weld tests of these as-cut edges were made for both manual and automatic cuts. Mechanical testing and metallurgical examinations of these welded specimens did not indicate any deleterious effects.

6. In the moving picture you may have noticed the large volumes of smoke coming from the cutting process. This bothered us when the equipment was installed in our plant. So we did some investigating to see if we could reduce it. I am glad to say we were able to reduce it from that shown to a whiff of smoke not much more than that of a cigarette, and definitely less than when welding with covered electrodes.

This is illustrated in the accompanying Fig. 9 which shows $^1/_2$ in. 6061–T6 aluminum plate being cut at 120 inches per minute. In these two photographs the only factor varied was the wire feed speed.

When arc voltage, wire feed speeds, and cutting speeds are properly balanced the volume of smoke from the cut can be greatly reduced.

Julius C. Ritter is associated with Boston Naval Shipyard, Boston, Mass.

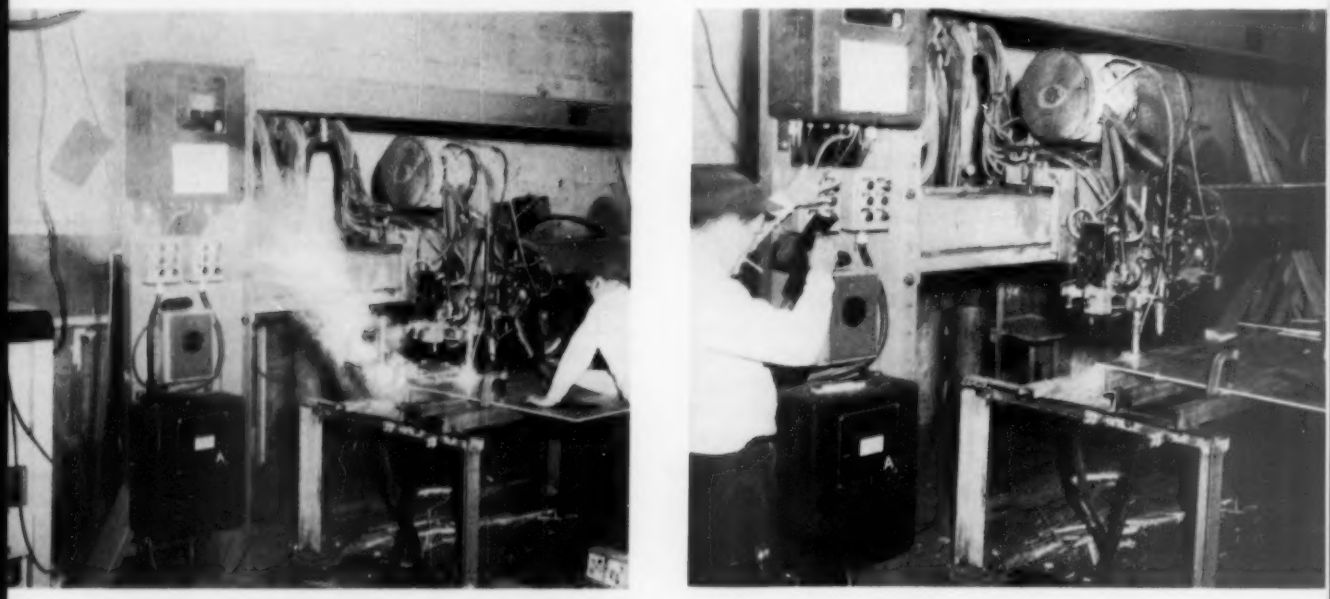


Fig. 9 These two photographs show the reduction of fumes achieved at Boston Naval Shipyard. Both cuts were made on same aluminum plate, with same equipment and same speed of cutting

AUTHOR'S REPLY

Being concerned with the development of the process as a whole, we have done some arc cutting of many materials in a variety of thicknesses. Mr. Ritter has applied his talents intensively to a few materials in a few thicknesses. As such, I have no reservation about accepting his comments as completely valid.

Most interesting are his remarks about fumes, because his ability to reduce these by proper adjustment of the conditions is indicative of the extent to which he has developed his application of this cutting process.

FABRICATION OF HEAVY GONDOLAS SPEEDED BY PROPER WELDING TECHNIQUES AND EQUIPMENT

BY ROBERT LOSEE

Combination a-c, d-c welding machines, used with two types of iron-powder electrodes—one for downhand welding in the flat position and one for all-position welding—resulted in exceptional economies in the recent fabrication of 45 gondola cars. Featuring exceptionally heavy and rugged construction, the 40-ft cars are for intraplant handling of coiled steel in carloads up to 100 tons. Builder was the Ortner Car Co. of Cincinnati, Ohio, a company specializing in the design, construction and repair of railroad rolling stock.

The combination a-c, d-c welding units are basically a-c machines, incorporating heavy-duty rectifiers for d-c operation. Dual controls provide regulation of arc characteristics to give either a soft arc or a forceful arc.

For long seams made in the flat position, an E6027, iron-powder electrode gave speeds up to 17 ipm. Typical were the joints between the four $^3/_8$-in. floor plates (Fig. 1), made in two passes, with a $^1/_2$- to $^3/_4$-in. gap; also the intermittent welds on heavy H-beam stiffeners for end sections (Fig. 2). In the latter, the avoidance of spatter led to easier preparation for painting and a better-looking paint job.

Floor support angles and fishbel'y support angles, welded to the $^3/_8$-in. side plates while clamped in a work-height fixture (Fig. 3), were handled by backstep welding in two directions from the centerline of the car. These deposits were in 20- to 22-in. increments, slightly overlapping, both over and under the angles, for a continuous, corrosion-sealing weld. This procedure avoided bowing of the side plate, experienced when the angles were welded continuously from one end to the other.

Bolsters and cross bearers (Fig. 4) were welded to the center sill while in position in an assembly fixture, requiring vertical, overhead and sloping welds. For this work, an improved type of iron-powder, E6013 electrode was used. It contains a large percentage of iron powder in the coating, although not as much or as heavy a coating as on the E6024 type. Speed and operat ng characteristics are of a high order, spatter is eliminated and a thin slag on the bead is self-cleaning. Practice called for two passes with $^3/_{16}$-in. rod. On all assemblies, preliminary tacking was done with an E6011 electrode.

Robert Losee is Welding Engineer, The Lincoln Electric Co., Cleveland, Ohio.

Fig. 1 Smooth, unobstructed interior of all-welded 40-ft gondola has no crevices where rust might start. Drain holes are provided at each corner. It will carry 100 tons of steel coils

Fig. 2 Clamped in a work-height fixture, $^3/_8$-in. end plate has heavy H-beam stiffeners, skip welded with iron-powder electrode, along with sturdy reinforcing angles top and bottom

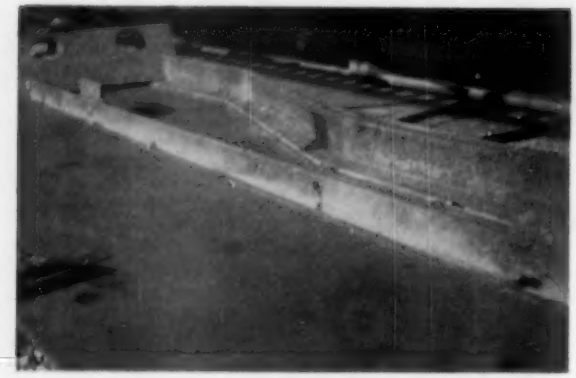


Fig. 3 Close-up of car side clamped in a 40-ft fixture for welding floor support angle and fishbelly or drop-center reinforcing angle. To avoid distortion, welds were made by backstepping in 20 to 22 in. lengths from the center-line

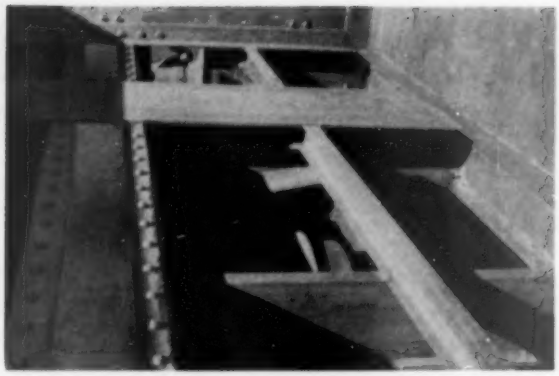


Fig. 4 Detail of floor framing, featuring double-web body bolsters, welded to center sill and sides with new all-position, iron-powder electrode. Cross bearer and stringer also are shown

From Fig. 4, it will be noted that the center sill is of riveted construction. Good, used trucks and center sills, which were structurally suitable, were used to keep costs as low as possible, while providing a car of high strength. Except for grab irons, all other construction was arc welded.

Body and frame members are some of the heaviest ever specified for gondola construction. For example, body bolsters have double-web plates; side stakes are H-beam sections instead of conventional formed sheet; double angles overlap around the entire car rim; and heavy angles are skip welded inside and outside of each corner. Side plates and floor plates are approximately 50% heavier than standard,

OXYACETYLENE AND INERT-ARC WELDING SPEED PRODUCTION OF LIGHT AIRCRAFT

Welding plays an important part in the production of small planes at the Taylorcraft Plant in Conway, Pa. The majority of the joints in these light aircraft are made by welding. This method of fabrication gives strength and minimum weight.

Oxyacetylene welding has particular advantages for joining the thin-wall SAE 4130 steel tubing that is used almost entirely for aircraft frames. The wide control of flame size and characteristics, and the ease of manipu-

Based on a story by the Linde Air Products Co., New York, N. Y.

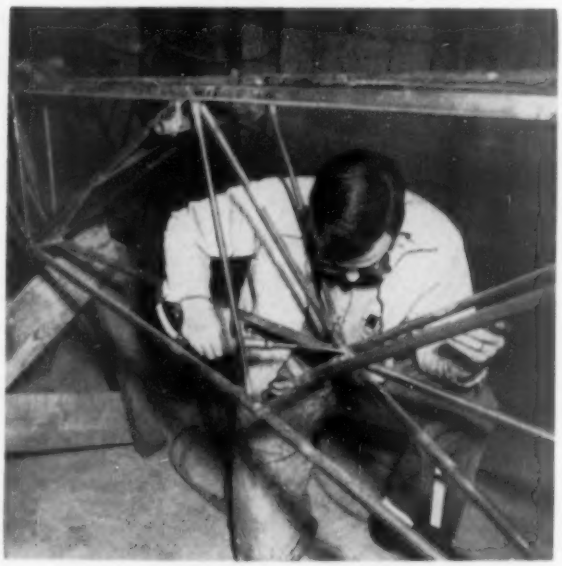


Fig. 1 Welding a cluster joint on the tail section of the main frame. Here the operator is using an oxyacetylene torch

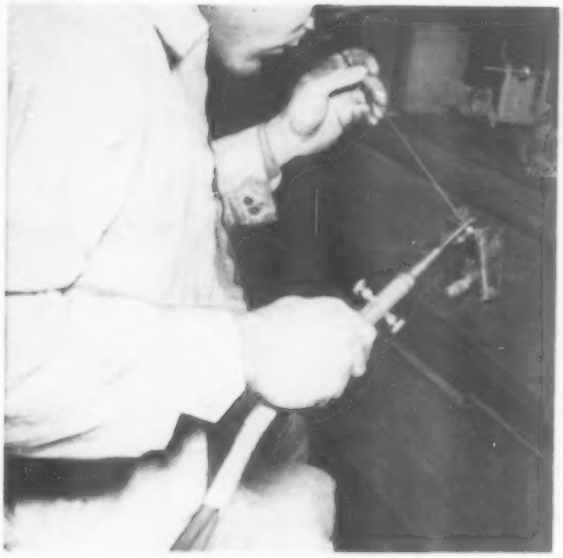


Fig. 2 A fuselage support is fabricated from SAE 4130 chrome-moly steel, 0.035 in. thick

Fig. 4 The landing gear is fabricated by oxyacetylene welding

lation possible with the oxyacetylene torch make it the preferred process for welding acute-angle joints. The operator easily controls the puddle on the thin-wall chrome-moly steel tubing and makes sound welds even in those areas where several struts come together.

Inert-gas tungsten-arc welding is particularly suited for the fabrication of aluminum and stainless steel parts wherever they are used on the plane. The inert-gas shield gives clean, sound welds and eliminates the use of flux, making postweld cleaning unnecessary. These two welding processes, inert-arc and oxyacetylene welding, especially as they are applied to light-gage materials, compliment each other and enable this careful work to be done quickly and easily (see Figs. 1 through 5).

Fig. 3 A steady hand helps the operator to weld a fabric clamp to the fuselage. The welded joints give maximum strength

Fig. 5 The operator welds aluminum with a gas-shielded tungsten-arc torch to produce a muff assembly

2-IN-1 WELDING

Single inert-gas welding gun used for both manual and machine welding on one job

BY GEORGE KOTCHER

Many welding jobs present a large variety of joints, some of which call for the maneuverability of manual welding, while others require the more stabilized conditions of machine welding.

Pabrico Steel Fabricators, Inc., of Paterson, N. J., recently undertook such a job—the production of a series of large brass hoppers used for storing gunpowder in arsenals. These hoppers of $^{3}/_{16}$-in. thick sheet measuring 47 in. square had a varying height of from 5 to 8 ft. The joints required both manual and machine welding.

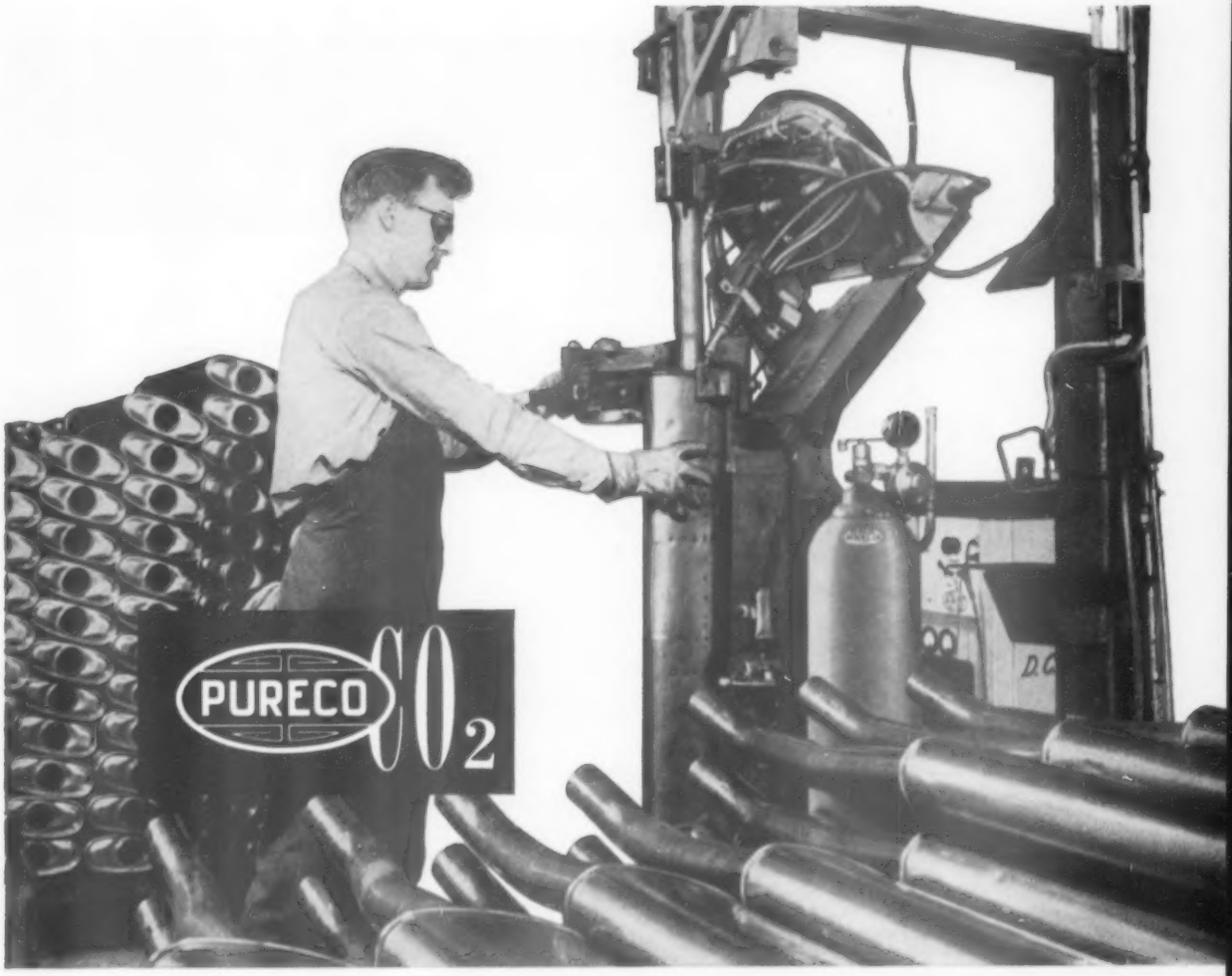
George Kotcher is a Technical Representative Air Reduction Sales Co., New York, N. Y.

Through a unique welding jig they had designed and built, Pabrico was able to consolidate the operation and save valuable man-hours. A single manual gas-shielded metal-arc welding gun was mounted on the jig to take advantage of high speeds on straight runs (see Fig. 1). Joints which could not be easily positioned for machine welding were welded manually by dismounting the gun from its fixed position (see Fig. 2). The welding gun's 10-ft. long flexible cable gave the operator a wide performance area when in manual use.

Thus, through versatile use of welding equipment, maximum efficiency was achieved—both manual and machine welding for special joints.

Fig. 1 Welding gun, mounted on overhead jig that moves along a rail allowing a 20-ft run on a straight line, makes machine welds on joints of large brass hopper

Fig. 2 Operator makes manual weld with welding gun dismounted from jig on other joints of brass hopper. Aluminum bronze welding wire and argon gas are used



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Society News

TECHNICAL PAPERS SESSIONS

1956 NATIONAL FALL MEETING

OCTOBER 8–12

HOTEL CLEVELAND, CLEVELAND, OHIO

AWS REGISTRATION

Mezzanine Area

Sunday, Oct. 7
3:00 P.M. to 6:00 P.M.
Monday, Oct. 8
8:00 A.M. to 4:00 P.M.
Tuesday, Oct. 9
8:00 A.M. to 4:00 P.M.
Wednesday, Oct. 10
8:30 A.M. to 4:00 P.M.
Thursday, Oct. 11
8:30 A.M. to 3:00 P.M.
Friday, Oct. 12
8:30 A.M. to 12:30 P.M.

Cleveland will be the scene of the 1956 AWS National Fall Meeting. Over 1200 AWS members are expected to attend and participate in the many activities planned for the five-day meeting from October 8th through October 12th. The hard-working Cleveland Section members, who are handling all the detail arrangements for the meeting, will act as hosts. Headquarters hotel and location of the meetings and social functions will be the Hotel Cleveland.

TECHNICAL ACTIVITIES

Twenty-one technical sessions are planned at which a total of sixty-four papers will be presented. Practically all phases of welding activity will be covered and latest developments will be reported on by authorities in the field.

As has been the custom in former years, the opening session, Monday morning, will be devoted to presentation of awards for achievement and service to the welding industry and the Society. Highlight of the session will be the Adams Lecture which is to be delivered by George E. Linnert of the Armco Research Laboratories. His talk will be on "Welding of Precipitation-Hardening Stainless Steels."

Another technical feature will be the educational lecture series which this year will deal with Resistance Welding.

PLANT TOURS

Two plant tours of unusually wide appeal have been arranged. On Wednesday morning, October 10th, members taking the tour will visit the Euclid Division of the General Motors Corp. and witness many different welding operations being used on tractors, scrapers, trucks and the like. On Thursday morning, October 11th, the Chevrolet Plant in Cleveland will be visited. Here, welding and fabrication of component parts for passenger cars and trucks will be observed.

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SOCIAL AND OTHER ACTIVITIES

Featuring the social activities will be the President's Reception on Monday night and the National Dinner on Wednesday night. An interesting ladies entertainment program has been planned for Monday through Thursday.

Throughout the week, numerous committee meetings will be held. The annual Welding Research Council University Conference and Dinner will take place on Wednesday evening.

Details of all Fall Meeting activities are listed in the accompanying pages. The official Program, which will be distributed to members and guests when they register, will contain more complete information.

OCTOBER 8, MONDAY MORNING

Official Opening Session—10:00 A.M.—Grand Ballroom

Chairman—*J. J. Chyle, President, American Welding Society*
Vice-Chairman—*J. E. Dato, Chairman, Convention Committee*

10:00 A.M.—President's Welcoming Address
10:15 A.M.—Prize Awards
10:30 A.M.—Adams Lecture

Welding of Precipitation-Hardening Stainless Steels
by George E. Linnert, Armco Research Laboratories

OCTOBER 8, MONDAY AFTERNOON

Three Simultaneous Sessions

1. STRUCTURES

Empire Room—2:00 P.M.

Chairman—F. L. Plummer
Hammond Iron Works
Co-Chairman—LaMotte Grover
Air Reduction Sales Co.

A. Behavior of Welded Built-Up Beams Under Repeated Loads
by J. E. Stallmeyer, W. H. Munse and B. J. Goodal, University of Illinois

B. Welded Open-Web Expanded Beams
by M. Altfillisch, B. R. Cooke and A. A. Toprac, University of Texas

C. Welded Reinforcement of Openings in Structural Steel Tension Members
by R. A. Hechtman and D. D. Vasarhelyi, University of Washington

2. WELDABILITY AND RESEARCH

Grand Ballroom—2:00 P.M.

Chairman—J. R. Henry
Cleveland Diesel Engine Div., G.M.C.
Co-Chairman—G. E. Claussen
Metals Research Laboratories

A. Notch Toughness Characteristics of Submerged-Arc Weld Deposits
by I. L. Stern, N. A. Kahn and H. Nagler, New York Naval Shipyard

B. Effect of Metallurgical Variables on Transition Behavior in Charpy Slow-Bend and Impact Tests
by C. E. Hartbower, Watertown Arsenal Laboratories

C. Mild-Steel Weld-Metal Porosity
by R. D. Stout, Lehigh University and J. T. Ballass, Electric Boat Division of General Dynamics Corp.

3. INERT-ARC WELDING

Whitehall Room—2:00 P.M.

Chairman—F. G. Flocke
The Thornton Company
Co-Chairman—R. C. Becker
International Harvester Co.

A. Factors Affecting Melting Rate of Gas-Shielded Metal-Arc Welding
by A. Lesnewich, Air Reduction Co., Inc.

B. Shielding Gases for Inert-Gas Welding
by W. H. Helmbrecht and G. W. Oyler, Linde Air Products Company

C. Inert-Gas Metal-Arc Welding of High-Pressure Valves
by F. R. Zacheus, Air Reduction Sales, Inc.

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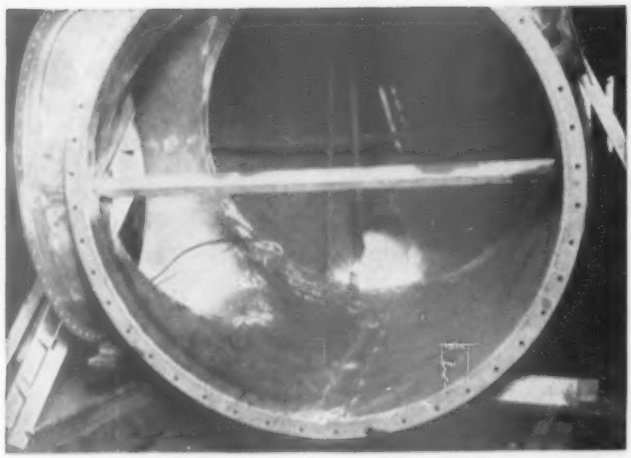

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OCTOBER 9, TUESDAY MORNING

Three Simultaneous Sessions

4. AIRCRAFT

Whitehall Room—9:30 A.M.

Chairman—F. G. Harkins
Solar Aircraft Co.

Co-Chairman—E. B. Morris
Grumman Aircraft Engineering Corp.

A. Design Requirements for Fusion Welding Titanium in Aircraft Applications
by R. Meredith, North American Aviation

B. Weld Planishing Improves Production of Aircraft Parts
by H. L. Meredith, Airline Welding and Engineering Co.

5. WELDABILITY AND RESEARCH

Grand Ballroom—9:30 A.M.

Chairman—A. Muller
Air Reduction Co., Inc.

Co-Chairman—A. G. Portz
Cleveland Welding Co.

A. Brittle Fracture Initiation Tests
by C. Mylonas, D. C. Drucker and L. Isberg, Brown University

B. Brittle Fracture Propagation in Wide Steel Plates
by W. J. Hall, R. J. Mosborg and V. J. McDonald, University of Illinois

C. The Effect of Microstructure on Notch Toughness and Fracture Morphology
by J. C. Danko, R. D. Stout and J. H. Gross, Lehigh University

6. DESIGN AND INSPECTION

Empire Room—9:30 A.M.

Chairman—R. J. Kriz
The James H. Herron Co.

Co-Chairman—R. B. Lincoln
Pittsburgh Testing Laboratories

A. Design, Fabricating and Erection Practices for Efficient Welded Highway Bridges
by O. Blodgett, The Lincoln Electric Co.

B. Industrial Radiography by Gamma Ray Projection from Radioactive Isotopes
by C. M. Dick, Metal & Thermit Corp.

C. Greater Acceptance of Welding Through the Use of Inspection Methods
by J. R. Harrer, Magnafluz Corp.

OCTOBER 9, TUESDAY AFTERNOON

Three Simultaneous Sessions

7. INERT-ARC WELDING

Grand Ballroom—2:00 P.M.

Chairman—W. H. Wooding
Philadelphia Naval Shipyard

Co-Chairman—O. H. Kuhlke
General American Transportation Corp.

A. Selection of Proper Inert-Gas-Shielded Arc-Welding Process
by C. J. Sullivan and I. D. Holster, Jr., Air Reduction Sales Co.

B. Consumable-Electrode Inert-Gas Welding with Small-Diameter Wires
by K. E. Richter and J. F. M. Essig, Linde Air Products Co.

C. Inert-Gas-Shielded Metal-Arc Spot Process
by J. W. Kehoe and H. J. Bichsel, Westinghouse Electric Corp.

8. TITANIUM

Whitehall Room—2:00 P.M.

Chairman—R. J. Krieger
Titanium Metals Corp. of America

Co-Chairman—F. J. Wallace
Pratt & Whitney Aircraft

A. An Investigation of the Weldability of Ti-6% Al-4% V
by D. M. Daley, Jr., and C. E. Hartbower, Watertown Arsenal Laboratories

B. Problems Involved in Spot Welding Titanium to Other Metals
by F. W. McBee, Jr., and J. H. Henson, Defense Research Laboratory and L. R. Benson, University of Texas

C. Effects of Interstitial Elements on Welds in Alpha Beta Titanium Alloys
by W. J. Lewis, M. L. Kohn, G. E. Faulkner and P. J. Rieppel, Battelle Memorial Institute

9. SYMPOSIUM ON METALLIZING

Empire Room—2:00 P.M.

Chairman—J. L. Cahill
New York Naval Shipyard

Co-Chairman—Bela Ronay
Consulting Engineer

Panel discussion sponsored by the AWS Committee on Metallizing

A. Surfacing and Build-up
by R. J. McWaters, Metallizing Engineering Co., Inc.

B. Ceramic Coatings
(Author to be announced)

C. Corrosion
by E. T. Englehart, Aluminum Research Labs.

D. Combination Coatings
by C. J. Breitenstein, Metal-Cladding, Inc.

ARCOS announces . . .

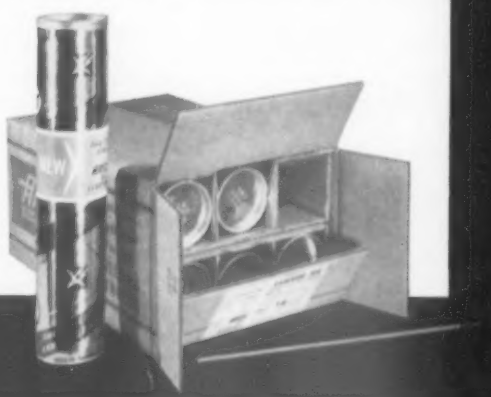
new easy-to-use DC electrodes

THE AEROCOR SERIES

Especially developed for DC reverse polarity welding of stainless sheet metal. Available in the following types: 308, 309, 310, 316, 347, 349, 410; sizes 1/16" to 1/8" dia.

THE FABRICOR SERIES

Especially developed for DC reverse polarity welding of heavy stainless. Available in the following types: 308, 309, 310, 316, 347; sizes 3/32" to 1/4".



Good news for every user of stainless electrodes

AEROCOR and FABRICOR identify America's newest DC welding electrodes.

To users they offer an opportunity for faster, easier welding. They've been especially designed for quality welds with the benefits and properties you want most.

For example, on every job, AEROCOR and FABRICOR Electrodes offer you these advantages:

- **Excellent arc action**
- **"Drag-type" welding technique**
- **Little or no spatter**
- **Superior washing action—good contours, sound penetration**
- **Smooth, even-rippled weld beads**
- **Slag that chips off quick and easy**

AEROCOR and FABRICOR are manufactured to the same high standards as all ARCOS Stainless Electrodes. And they're packaged in the famous Arcos ELECTROPAK — the easy-to-open-and-reseal container that protects against moisture pick-up and chipped coatings. Both series are identified by a bright orange colored label. Available through your Arcos representative or distributor.

FREE PERFORMANCE TEST

See the results in your own plant. Compare the performance of these new ARCOS Electrodes to what you're now using. Just drop us a line on your company letterhead and we'll arrange a demonstration. No obligation, of course.

More than ever it pays to . . . **WELD WITH ARCOS**

ARCOS CORPORATION • *1500 South 50th Street* • *Philadelphia 43, Pa.*

OCTOBER 10, WEDNESDAY MORNING

Three Simultaneous Sessions

10. BRAZING AND SURFACING

Empire Room—9:30 A.M.

Chairman—W. A. Black
Republic Steel Corp.
Co-Chairman—E. T. Scott
The Cleveland School of Welding, Inc.

A. Silver Brazing Lap Joints in Stainless Steel Tubing
by G. H. Bohn, Linde Air Products Co.

B. Basic Characteristics of Some Heat-Resistant Brazing Filler Materials
by W. H. Chang, General Electric Co.

C. Longer Service Life Through Hard Facing for Petroleum Industry Equipment
by H. S. Gonser, Wall Colmonoy Corp.

11. FILLER METAL

Whitehall Room—9:30 A.M.

Chairman—L. K. Stringham
The Lincoln Electric Co.
Co-Chairman—P. C. Arnold
Chicago Bridge & Iron Co.

A. A New Nodular Cast-Iron Welding Rod for Foundries and Fabricators
by R. O. Day, J. S. Snyder and H. V. Inskeep, Linde Air Products Co.

B. Coating Ingredients Influence on Surface Tension, Arc Stability and Bead Shape
by T. H. Hazlett, University of California

C. Electrode Control in an Alloy Pressure Vessel Plant
by W. W. Weber, The Colonial Iron Works Co.

12. PIPING AND PIPELINES

Grand Ballroom—9:30 A.M.

Chairman—R. J. Landrum
E. I. du Pont de Nemours & Co.

Co-Chairman—G. L. Martin
U. S. Steel Corp.

A. Status of Efforts to Develop Nonmanual Pipe-Line Welding Methods
by P. S. Reed, The Oil and Gas Journal

B. Automatic Welding of Piping
by H. Thielsch, Grinnell Co., Inc.

C. Automatic Welding Applications at the Whiting Refinery
by R. C. Wheeler and R. M. Kolb, Standard Oil Co.

OCTOBER 10, WEDNESDAY AFTERNOON

Three Simultaneous Sessions

13. RESISTANCE WELDING

Empire Room—2:00 P.M.

Chairman—Jack Ogden
Fisher Body Div., G.M.C.

Co-Chairman—A. L. Pfeil
Universal Welder Corp.

A. Recent Developments in Magnetic Force Welding
by E. J. Funk, Precision Welder & Flexopress Corp.

B. Regulated and Programmed Resistance Welding Control Systems
by C. Sinclair, General Electric Co.

C. Comparative Analysis of Finish Seam Welding and Mash Seam Welding
by M. L. Begeman and W. J. Allen, University of Texas

14. STAINLESS STEEL

Grand Ballroom—2:00 P.M.

Chairman—R. D. Wylie
Babcock & Wilcox Co.
Co-Chairman—E. F. Nippes
Rensselaer Polytechnic Institute

A. Properties of Austentic Chromium-Manganese Stainless-Steel Weld Metal
by W. T. DeLong and H. F. Reid, The McKay Company

B. The Plastic Ductility of Welded Joints in Austenitic-Steel Piping at 1200°
by R. W. Emerson and R. W. Jackson, Pittsburgh Piping and Equipment Co.

C. Further Studies on Stainless-Steel Hot Cracking
by H. Rischall and P. P. Puzak, Naval Research Laboratory

15. PRESSURE VESSELS

Whitehall Room—2:00 P.M.

Chairman—J. L. Menson
Combustion Engineering, Inc.
Co-Chairman—R. G. Chapman
The Colonial Iron Works Co.

A. Fabrication of Inert-Gas Welded Aluminum Tanks and Pressure Vessels
by R. J. Franz and Amel R. Meyer, Graver Tank and Manufacturing Co., Inc.

B. The Properties of Pressure-Vessel Steels in Heavy Sections
by J. H. Gross and R. D. Stout, Lehigh University

C. Investigation of a Pressure Vessel Failure
by J. Heuschkel, Westinghouse Research Laboratories

Announcing

SYLVANIA

Color Coded

TUNGSTEN ELECTRODES

✓ for quick identification
✓ for safety and economy

Now—at no extra cost—all Sylvania Tungsten Electrodes are supplied with *color coded* ends. You can tell the type of rod at a glance, even if the carton has been lost or destroyed.

Never again will you have to scrap used lengths of rod because you can't identify them. And never again will you risk ruining a costly job because of using a wrong electrode. With Sylvania's new color coding—you'll always know *for sure* what rod you have in your electrode clamp!

Add to color coding, the many other advantages of Sylvania Tungsten Electrodes . . . and you'll agree they're your best buy! Only Sylvania has the *complete* line—four types of electrode, each designed to do a specific job in shielded arc welding.

Whether you use atomic hydrogen, helium or argon in your arc welding . . . you'll find that the four dependable Sylvania Tungsten Electrodes will meet almost any condition you may encounter.

Sylvania Tungsten Electrodes are supplied with chemically cleaned or centerless ground finish. Order them in handy color coded packages of ten from your welding supplies distributor. For further information write to:

SYLVANIA ELECTRIC PRODUCTS INC.
Tungsten & Chemical Division
Towanda, Pa.

SYLVANIA

Lighting • Radio • Electronics • Television • Atomic Energy

OCTOBER 11, THURSDAY MORNING

Three Simultaneous Sessions

16. WELDING AND CUTTING

Empire Room—9:30 A.M.

Chairman—J. H. Zimmerman
Linde Air Products Co.
Co-Chairman—R. E. Stein
Lewis Welding & Engineering Corp.

A. Aspects of Crack Sensitivity in Machinable Deposits on Cast Iron
by R. D. Wasserman, J. F. Quaas and J. Broderick, Eutectic Welding Alloys Corp.

B. Fundamental Concepts of Oxygen Cutting
by R. L. Stoecker and W. B. Moen, Air Reduction Co., Inc.

C. Transverse Cracking Resulting from Oxygen Cutting
by N. N. Breyer, Continental Foundry & Machine Division of Blaw-Knox Company

17. ALUMINUM

Grand Ballroom—9:30 A.M.

Chairman—M. A. Miller
Aluminum Co. of America
Co-Chairman—W. M. Boam
Curtiss-Wright Corp.

A. The Thermal Stability of Cold Butt Welds in Aluminum and Copper
by W. H. Bruckner and J. H. Sayles, University of Illinois

B. Fabricating Aluminum With Other Metals
by K. V. Lutz, All-State Welding Alloys Co., Inc.

18. PIPING AND TUBING

Whitehall Room—9:30 A.M.

Chairman—H. T. Herbst
United Tube Corp.
Co-Chairman—I. H. Carlson
Crane Co.

A. Study of Interrupted Welding of Heavy-Wall Steam Pipe
by I. A. Rohrig, J. O. Smith and E. G. Shifrin, The Detroit Edison Company

B. Welding Heavy-Wall Carbon-Steel Pipe with CO_2 Shielding Gas
by A. B. Dunning, General Electric Co.

C. Effect of Zinc Phosphate Coatings on Flash Welding of Steel Tubing
by J. F. Young and A. Phillips, Douglas Aircraft Co., Inc.

OCTOBER 12, FRIDAY MORNING

Three Simultaneous Sessions

19. MOLYBDENUM AND ZIRCONIUM

Empire Room—9:30 A.M.

Chairman—W. L. Warner
Watertown Arsenal
Co-Chairman—Harry Udin
Suburban Metallurgical Laboratory

A. Ductility of Tungsten-Arc Welds in Molybdenum
by R. E. Monroe, N. E. Weare and D. C. Martin, Battelle Memorial Institute

B. The Influence of Nitrogen on the Ductility of Molybdenum Welds
by W. N. Platte, Westinghouse Electric Corp.

C. Notch Slow-Bend Testing of Zircaloy-2
by R. G. Wheeler, General Electric Co.

20. PROCESSES

Whitehall Room—9:30 A.M.

Chairman—T. J. Crawford
Consulting Engineer
Co-Chairman—Ralph Hennie, Jr.
Republic Steel Corp.

A. The Motor Arc Welding Process
by C. C. Stone and R. A. Noland, Argonne National Laboratory

B. High-Frequency Continuous Seam Welding of Ferrous and Non-Ferrous Tubing
by H. B. Osborn, Jr., The Ohio Crankshaft Co.—TOCCO Division

C. Developed Procedures for the Flexible-Electrode-Submerged-Arc Welding Process
by M. H. Fritsche, Westinghouse Electric Corp.

21. SHOP MANAGEMENT

Grand Ballroom—9:30 A.M.

Chairman—Lew Gilbert
Industry & Welding
Co-Chairman—L. S. Cawrse
Consolidated Iron-Steel Mfg. Co.

A. Organization of Shop Management for Quality Welding
by W. B. Bunn, Combustion Engineering, Inc.

B. Maintaining Workmanship Standards for Quality Welding
by Howard B. Cary, Marion Power Shovel Co.

EDUCATIONAL LECTURE SERIES

Empire Room

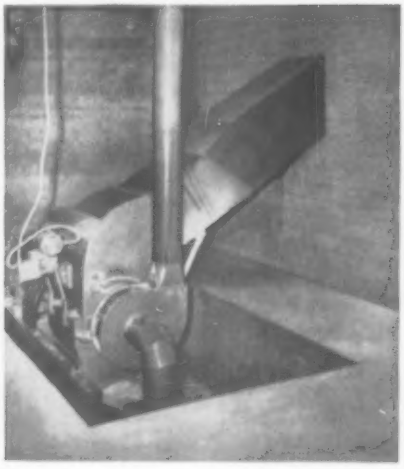
TUESDAY, OCTOBER 9, 4:30 TO 6:00 P.M.
WEDNESDAY, OCTOBER 10, 4:30 TO 6:00 P.M.

Resistance Welding—Theory and Use

HOW USS "T-1" STEEL IMPROVES THESE PRODUCTS...

Lower-Cost Dirt. This mammoth coal stripping machine scoops out 2000 cu. yds. of overburden an hour, cuts the cost of stripping coal that lies under 50 to 80 ft. of overburden. Its 22-ft. wheel carries eight buckets, each 4 ft. wide, with lips of 2½-inch USS "T-1" Steel. USS "T-1" Steel has the strength and toughness to scrape through shale, rock, mud, and ram into ton-and-a-half boulders day in and day out. In addition, it is weldable in the field, costs less than other steels that could be used—and outlasts them. This wheel excavator was designed by United Electric Coal Companies, Chicago, for their own use.

Heavier Loads, More Production. Mack Welding Company, Duluth, Minnesota, has used USS "T-1" Steel to increase the durability and at the same time reduce the weight of its Orange Peel Type, Four Tine Pulpwood Grapples. With these new, lightweight grapples, crane operators can handle increased payloads with present cranes. As a result, production can be increased as much as 40 percent.



Shucks, hay fodder, corn cobs, and grains are extremely abrasive when sucked out of a hammermill at high speed. And the blades of the fan that does the sucking must be able to withstand the abrasion and must be weldable. Myers-Sherman Company, Streator, Illinois, manufacturers of industrial hammermills, now make these fan blades from USS "T-1" Steel and save $7 on fabrication of each fan. USS "T-1" Steel provides all the needed durability, as well as good weldability.

Moloney Saves A Ton. The size of everything had to be reduced on this new, smaller-than-ever portable transformer designed by Moloney Electric Company, St. Louis, Missouri. Over a ton of weight was saved in the tank alone by building it of ¼-inch USS "T-1" Steel instead of ⅜-inch carbon steel. The very high strength of this heat-treated alloy steel made possible this 25% saving in weight. The excellent weldability of USS "T-1" Steel was important, too, because this portable transformer is permanently welded to the bed of a semi-trailer. This particular unit was designed for Oklahoma Gas & Electric Corporation. Shell was fabricated by Nooter Corporation, St. Louis.

HOW IT CAN HELP YOU

USS "T-1" Steel, with its high minimum yield strength of 90,000 psi and its minimum tensile strength of 105,000 psi, can help you design or build lighter-weight equipment that will last longer. Its unusual toughness can help you design or build equipment capable of taking severe impact and abuse at sub-zero temperatures. Its excellent weldability can help you cut the cost of fabricating high strength parts, and to reduce repairs and maintenance expense.

Somewhere in your operation, versatile USS "T-1" Steel can help you. Write, wire, or phone United States Steel, Room 5418, Pittsburgh 30, Pa.

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.

UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T1" CONSTRUCTIONAL ALLOY STEEL

See The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL

OTHER ACTIVITIES

OCTOBER 8, MONDAY EVENING

6:00 P.M.—President's Reception—Grand Ballroom

OCTOBER 10, WEDNESDAY EVENING

National Dinner
6:00-6:30 P.M.—Cocktail Hour
7:00 P.M.—Dinner in Grand Ballroom
Music and professional acts
9:30-12:00 P.M.—Dancing

6:30 P.M.—WRC University Dinner—Mezzanine Rooms 1, 3 and 5

8:00 P.M.—WRC University Conference—Parlors 34 and 36

OCTOBER, 11, THURSDAY MORNING

10:00 A.M.—Board of Directors' Meeting—Parlors 34 and 36

WELDING AND CUTTING EXHIBITS AND DEMONSTRATIONS
NATIONAL METALS EXPOSITION

Public Auditorium
Cleveland, Ohio

Hours of the Exposition

Monday, October 8	·	*12 Noon to 10:30 P.M.*
Tuesday, October 9	·	*12 Noon to 10:30 P.M.*
Wednesday, October 10	·	*12 Noon to 10:30 P.M.*
Thursday, October 11	·	*10:00 A.M. to 6:00 P.M.*
Friday, October 12	·	*10:00 A.M. to 6:00 P.M.*

Admission by special invitation or by AWS registration badge or membership card of any participating society.

PLANT TOURS

The Euclid Division of General Motors Corp. in Cleveland has been selected for a plant tour on Wednesday, October 10th.

On Thursday, October 11th the Chevrolet-Cleveland Division of General Motors Corp., also in Cleveland, will be visited.

Buses for both tours will leave Hotel Cleveland (Public Square Entrance) at 9:00 A.M. Wednesday, October 10th and Thursday, October 11th. Buses will return to Hotel Cleveland by 12:30 P.M. on both days.

At the Euclid plant on Wednesday morning manual, semiautomatic, and automatic arc welding and flame cutting will be seen in the production of the Euclid Crawler Tractors. Unique use of positioners in handling heavy fabrications in subassembly groups as well as the assembly methods will be shown. Some of the subassemblies made in this plant are for the other Euclid products—wheeled tractors, scrapers and trucks for "off the road" uses. The tour will include the final assembly line and test area.

The tour through the Chevrolet Plant on Thursday morning will include the automatic tube mill operation, making tubing for truck and passenger car propeller shafts. Visitors will also see the assembly and welding of the tubing and forgings into the completed propeller shaft by automatic arc welding. An extensive installation of resistance welding equipment combined with press equipment to produce truck fenders, hoods and sheet metal parts exemplifies today's role of "automation or integration" in welding.

Induction brazing plays an important part in the low-cost production of "Powerglide" automatic transmissions. Automatic "CO_2" welders and spot welders team up to weld a steel band on a die cast impeller and secure the balancing weights.

NOTE: Persons making the Chevrolet Tour *must* sign an affidavit indicating United States Citizenship at the Chevrolet Plant Lobby prior to making the tour.

LADIES' PROGRAM OF ACTIVITIES

Parlor 31 on the Parlor floor of the Hotel Cleveland is the Ladies' Headquarters and Lounge. Here they will register, meet and visit with friends, and take coffee and sweet rolls each morning from 9:00 to 11:00 A.M.

Registration

Sunday, October 7, 4:00 to 5:00 P.M.
Monday, October 8, through Thursday, October 11, 9:00 A.M. to 4:00 P.M.
Friday, October 12, 9:00 A.M. to 11:00 A.M.

Sunday, October 7

5:00 to 7:00 P.M. "Early Bird" social hour

Monday, October 8

9:00 to 11:00 A.M. Coffee hour, Parlor 31, Hotel Cleveland
1:00 P.M. Luncheon at Halle Bros., 7th floor tea room. Models will exhibit newest winter fashions (return to Hotel by 2:30 or 3:00 P.M. if desired)
6:00 P.M. President's Reception at Hotel Cleveland

Tuesday, October 9

9:00 A.M. Coffee hour, Parlor 31, Hotel Cleveland
11:00 A.M. Sightseeing bus tour through interesting cultural and educational centers of Cleveland, ending with lunch at Stouffer's Shaker Square Restaurant (back to Hotel by 3:30 or 4:00 P.M. via Rapid Transit)

Wednesday, October, 10

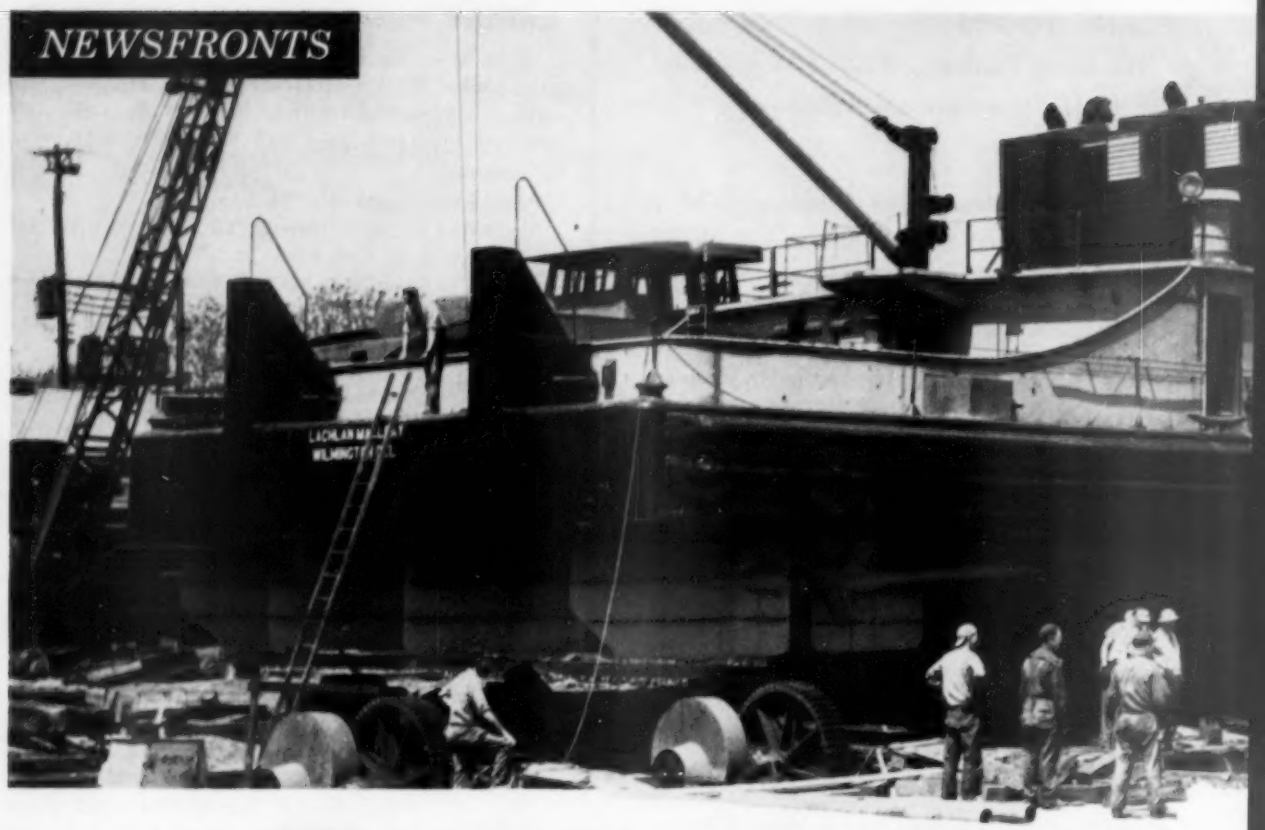
9:00 to 11:00 A.M. Coffee hour, Parlor 31, Hotel Cleveland
2:15 P.M. Matinee at nearby Hanna Theatre. Broadway production.
6:30 P.M. Cocktails with men—Hotel Cleveland
7:00 P.M. Banquet, Grand Ballroom, Hotel Cleveland

Thursday, October 11

9:00 to 11:00 A.M. Coffee hour, Parlor 31, Hotel Cleveland
12:00 Noon Buses will leave Hotel Cleveland for luncheon at Acacia Country Club. Talk by well-known Cleveland personality, Mrs. Sidney Andorn, on the history, beliefs and arts of the Shakers, early settlers of the Shaker Heights area (bus to Hotel by mid-afternoon)

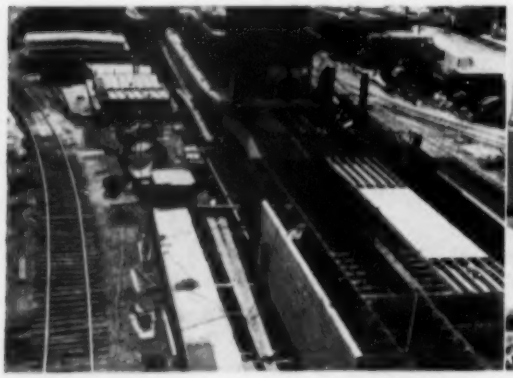
Friday, October 12

9:00 to 11:00 A.M. Coffee hour. Parlor 31, Hotel Cleveland
Open day for shopping, viewing the exhibits, a trip to the observation platform of the Terminal Tower (tallest building west of New York City), or if desired, a game of cards in the Ladies' Headquarters and Lounge, Parlor 31, at Hotel Cleveland

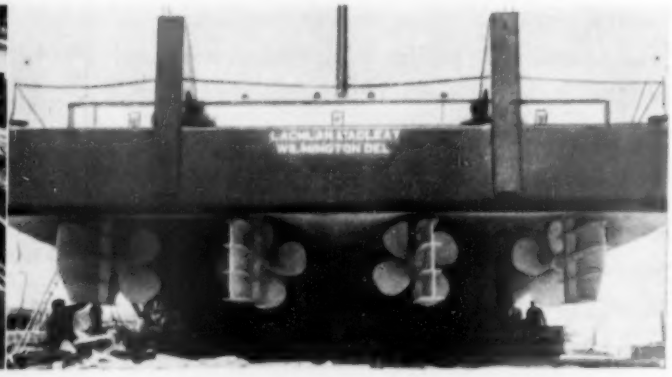


Built to foil

Largest barge pusher ever built for Missouri River service. Knowing the river's way of throwing up shifting sand bars and other obstacles, St. Louis Shipbuilding built in plenty of reserve strength . . . did much of the welding with SW-10 A. O. Smith electrodes



Lachlan Macleay begins to shape in St. Louis Shipbuilding's ways. Most of welding is multi-pass on heavy gauges. The barge pusher is 165 ft. long.



Four 900-hp diesel engines turn these 78-inch steel alloy propellors. A sister ship of the Lachlan Macleay is currently under construction.

a tricky river

In addition to 3600 horsepower, the Lachlan Macleay had to have shallow draft and extra strength in hull construction.

Welding, primarily, is on ½ and ⅜-inch plate. To insure watertight welds — welds with less chance of being sprung should the Lachlan Macleay hit sudden underwater obstacles — St. Louis Shipbuilding & Steel Co. is using SW-10 (E-6010) A. O. Smith electrodes.

Similarly, if you use welding in your work you, too, can insure the quality of welds . . . be positive you're getting maximum strength and dependability at lowest overall cost by specifying A. O. Smith electrodes. As thousands of users can tell you, A. O. Smith quality doesn't cost, it pays — in terms of less welding time, money and trouble. Why not get the complete story from your "man from A. O. Smith" today?

The man from A. O. Smith

. . . Hal Costello is the A. O. Smith welding consultant who worked with St. Louis Shipbuilding. More than a salesman, he's a welding specialist, ready and eager to help with any welding problem.

PRODUCED BY WELDERS — FOR WELDERS — Because welding is our full-time business, we offer you America's finest welder-proved electrodes, machines and accessories.

Through research A.O. Smith *. . . a better way*

A.O.Smith

CORPORATION

WELDING PRODUCTS DIVISION

Milwaukee 1, Wisconsin

International Division: Milwaukee 1, Wisconsin

New England Regional Conference on Welding

Sponsored by the *Boston* Section, AWS

New England Mutual Hall, Boston, Mass.

Wednesday, Sept. 19, 1956

Program

9:30 a.m.—Registration

10:00 a.m. to 1:00 p.m.—Morning Sessions

1. "The Mechanism of Brazing," Dr. Harry Udin, Director, Suburban Metallurgical Lab.
2. "Hot Ductility Studies," Dr. Warren F. Savage, Rensselaer Polytechnic Institute
3. "A Weld Crack Susceptibility Test," J. S. Boudreau, General Electric Co.

1:00 to 2:30 p.m.—Lunch

2:30 to 5:30 p.m.—Afternoon Sessions

1. "The Mechanism of Brazing," Dr. Harry Udin, Director, Suburban Metallurgical Lab.
2. "Hot Ductility Studies," Dr. Warren F. Savage, Rensselaer Polytechnic Institute
3. "A Weld Crack Susceptibility Test," J. S. Boudreau, General Electric Co.
4. "The Fabrication of Titanium," C. E. Hartbower, Watertown Arsenal
5. "Recent Advances in Welding Electrodes," Dr. Hallock Campbell, Arcos Corp.
6. "Inert-Gas-Shielded Metal-Arc Welding," Dr. J. S. Parks, Air Reduction Co.

The Boston Section extends a hearty welcome to all those in the New England area interested in the advance of welding. Late registrants may contact Alan Rosenberg, Chairman, Conference Committee, General Electric Co., 950 Western Ave., Lynn, Mass., or telephone Lynn 3-6000, Ext. 3606.

Mark Your Calendar
NOW!
October 8–12, 1956
AWS National Fall Meeting
Hotel Cleveland
Cleveland, Ohio

To All Electrode and Welding Rod Suppliers

The AMERICAN WELDING SOCIETY receives a great many inquiries dealing with filler metals and their classifications. (Filler metals are classified by a joint committee of the AMERICAN WELDING SOCIETY and the American Society for Testing Materials.) The questions most often asked are:

1. What classification is Brand X?
2. Is Brand X the same classification as Brand Y?
3. Who makes it and distributes it?

Although some manufacturers print charts showing this information, none of these charts are all-inclusive enough to adequately answer most inquiries. In many cases, it is necessary to consult a number of different manufacturers' catalogs before the answer is obtained. In other cases, the information is not available.

In order to alleviate this situation, it has been decided to publish a comprehensive chart (or group of charts) showing the AWS-ASTM classifications and all filler metals, by brand name, that are in these classifications.

Letters have been sent to all known filler metal firms requesting their aid in the preparation of these charts. These organizations have been asked to indicate, on a form, those filler metals (by brand name) being manufactured or distributed by them.

Organizations wishing to have their filler metals listed should prepare a tabulation of their brand names and the corresponding AWS-ASTM classifications. If uncertainty exists regarding correct AWS-ASTM classifications, a form showing all classifications can be obtained from the AWS. This information should be sent to Assistant to Technical Secretary, American Welding Society, 33 W. 39th St., New York 18, N. Y., *not later than Oct. 15, 1956.*

Public Service Enrolls as Supporting Company Member

One of the latest organizations to enroll as a Supporting Company Member of AWS is the Public Service Company of New Hampshire, 1087 Elm St., Manchester, N. H. The enrollment went into effect August 1st.

•

Warner & Swasey Co. Becomes Sustaining Member

The Warner & Swasey Co., Cleveland, Ohio, has recently become a sustaining member of AWS. Since its founding in 1880, this company has been a leading manufacturer of machine tools. In its early history, telescopes and other optical instruments were included among its products. Most of the large telescopes in use today were designed and made by this Company.

Following World War II, diversification led to the manufacture of textile machinery and earth-moving equipment. The latter product, the Gradall, is manufactured in a branch plant in New Philadelphia, Ohio. Another plant which manufactures the Gradall undercarriage, is located in Lansing, Mich.

C. D. Hatch has been designated sustaining member representative.

Clark and Young Nominated by ASM

A California university professor and a Canadian aluminum scientist have been nominated to fill the two top offices of the American Society for Metals.

Nominated for president was Dr. Donald S. Clark, professor of mechanical engineering, California Institute of Technology, Pasadena, Calif., currently serving as Society vice-president. George M. Young, technical director of The Aluminum Company of Canada, has been selected as vice-president. Retiring president is A. O. Schaefer, director of research, Midvale-Heppenstall Co., Philadelphia, who automatically becomes a member of the Board of Trustees.

As treasurer, C. H. Lorig, assistant director, Battelle Memorial Institute, Columbus, Ohio, continues into his second year.

As secretary of the American Society for Metals, W. H. Eisenman, Cleveland, Ohio, has been selected for his 20th two-year term by a special committee comprised of past presidents of the Society. Eisenman has been directing secretary for 38 years.

The new officers will be inducted at the annual meeting of the Society held in Cleveland during the 39th annual National Metal Exposition and Congress October 8th to 12th.

EMPLOYMENT SERVICE BULLETIN

Positions Vacant

Superintendent, Welding Laboratory, $10,320.00 a year, U.S. Naval Engineering Experiment Station, Annapolis, Maryland. Has administrative and technical administration of the Welding Laboratory which is concerned with applied research for the weldability of metals, development of welding procedures, welding materials, test procedure and suitability of weldments. Serves as a technical adviser and consultant to the Director of the Station, the Bureau of Ships and other laboratories.

Applicants should have a degree in metallurgical engineering and have at least four years of progressively responsible experience in the general field, including at least one year of very high level experience in welding engineering, metallizing and application of hard surface alloys.

Application should be filed with the Industrial Relations Officer, U.S. Naval Engineering Experiment Station, Annapolis, Maryland, by October 15, 1956.

Mechanical Engineer. K-G Welding Equipment Division offers an unusual opportunity to an experienced design and development engineer on gas welding and cutting apparatus. If you are stymied and are ready to take a position of senior responsibility with an alert growing organization, send your qualifications in confidence to B. H. Van Dyke, Air Products, Inc., P.O. Box 538, Allentown, Pa.

Sales positions available. Expanded facilities of a prominent manufacturer of welding equipment makes it possible for them to augment their field coverage. This company is a Bay City, Mich., concern which designs and manufactures a complete line of resistance welding machines including all standard and special types. In addition the company designs and builds special arc welding equipment. At the present time it has several machines and special tooling in operation in practically all of the major automotive and appliance plants and their allied industries.

Sales experience in this particular type of equipment is desired, but consideration will be given to men with engineering knowledge in the resistance welding field.

Please list your education and your employment record in your reply. United Welders, Inc., 3036 Twelve Mile Rd., Berkley, Mich.

V-337. Editorial–Sales Opportunity. With national engineering society monthly publication. Resourceful, capable assistant wanted to sell advertising space and to aid with overall editorial and production activities. Field closely allied to metallurgy and metal fabrication. In reply please outline experience, personal history and salary requirements.

Many Thanks!

About the time that this September Journal reaches you, your Secretary should be back in, at least, "walking harness" at AWS headquarters. From then on, he should gain speed and begin to operate in the customary full gear again. The doctors say that his chances for reaching 100 are better now than ever. Stick around with us—we will see!

There are some compensations for prolonged confinement. Among these, is the "lift" one receives from cheery letters, notes and cards from good friends, near and afar.

To answer all—one by one, as courtesy and appreciation dictate—would be an impossible task within the available time interval. So, if he may have your permission to do so, your Secretary wishes to make use of this space to register his sincerest, heartfelt appreciation for those uplifting thoughts, warm good wishes for recovery, and all together cheering messages he has received during the past few weeks.

Thanks, —much.

Joe Magrath

WANTED!
NOW

PHYSICAL METALLURGISTS, minimum of 5 years experience with heat-resistant materials.

WELDING ENGINEERS with extensive experience in spot, seam, flash, arc, heliarc, automatic heliarc and consumable electrode welding of aircraft materials. Positions are in metallurgical section of engineering department and involve research, development and consultation with design engineers.

PHYSICAL METALLURGISTS with experience, to coordinate with design groups in the development of aircraft castings with optimum properties.

THIS IS an exceptional opportunity for men with thorough training and experience. Complete technical facilities are available, and working conditions are ideally satisfactory.

ADEQUATE HOUSING in all price ranges, thousands of acres of lakes and parks, a low cost of living (no state sales or income tax), and a mild year around climate make leisure time interesting and relaxing.

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—High-Temperature Metallurgy
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Section News and Events

as reported to Catherine O'Leary

American Welding Society Forms Three New Sections

Three new sections have been formed by the AMERICAN WELDING SOCIETY to bring the total of active sections throughout the nation to 81.

One of the newly activated sections covers the area in and around Utica, N. Y., and will be known as the Mohawk Valley Section. Its officers are: D. A. St. Louis of A. H. St. Louis Co., chairman; R. E. Runyon, General Electric Co., 1st vice-chairman; M. H. Colerick, Colerick Supply Co., Inc., secretary; and H. Niemczyk, New Hartford Sheet Metal Works, treasurer.

Another of the new sections has been organized in San Antonio, Tex. Known as the San Antonio Section, it formerly functioned as a division of the Houston Section. Its officers are: R. D. Sprague, Campbell Steel Co., chairman; J. R. Johnson, H. B. Zachry Co., 1st vice-chairman; J. A. Rounds, Earle M. Jorgensen and Co., 2nd vice-chairman; D. T. Hobbs, C. L. Hobbs Sons, secretary; and C. E. Hosier, Linde Air Products Co., treasurer.

The third new section will service the region in and around Canton, Ohio, and will be known as the Stark Central Section. Its officers are: E. W. Rowlands, Griscom-Russell Co., chairman; I. W. Evans, Morgan Engineering Co., 1st vice-chairman; R. Kewley, Lincoln Electric Co., 2nd vice-chairman; F. Howard, Jr., Canton Welders Supply Co., secretary; and E. Van Sickle, Warner and Swasey Co., treasurer.

SECTION MEETING CALENDAR

SEPTEMBER 7

NORTH CENTRAL OHIO Section. Plant tour of the National Machinery Co., Tiffin, Ohio. Dinner prior to tour will be at the Shawhan Hotel. Dinner at 6:30; plant tour at 8:00 P.M.

SEPTEMBER 17

PHILADELPHIA Section. Drexel Institute of Technology, Philadelphia. 8:00 P.M. First session of educational program. AWS President John J. Chyle will address group on "Factors in the Selection of Welding Processes"; Harry W. Pierce, past president, will be dinner speaker. His topic will be "Need for Technical Education in the Welding Field."

SEPTEMBER 24

OLEAN-BRADFORD Section. Valley Hunt Club, Lewis Run, Pa. "Maintenance Welding" by L. D. Richardson, sales manager of Eutectic Welding Alloys Corp., N. Y. C.

OCTOBER 5

PHILADELPHIA Section. 8:00 P.M. Engineers Club, 1317 Spruce Street. Panel discussion on general subject of Welding Questions and Answers. Panel: Charles Dooley, Sun Ship. & D. D. Corp., Chester, Pa., Walter Mehl, Heintz Mfg. Co., Philadelphia; H. C. Campbell, Arcos Corp., Philadelphia.

OCTOBER 15

PHILADELPHIA Section. 8:00 P.M. Engineers Club. "A New Concept in the Fabrication and Launching of Vehicular Tunnel Tubes" by F. P. Iapalucci, C. J. Ascenzi and S. W. Gearhart, Jr., Baldwin-Lima-Hamilton Corp.

OCTOBER 29

OLEAN-BRADFORD Section. 7:00 P.M. Castle Restaurant, Olean, N. Y. Joint meeting with the American Society of Mechanical Engineers. "Product Design for Welding" by John Mikulak, assistant to vice-president in charge of manufacturing, Worthington Corp., Harrison, N. J.

Editor's Note: Notices for December meetings must reach Journal office prior to October 1, so that they may be published in November Calendar. Give full information concerning time, place, topic and speaker for each meeting.

ANNUAL PICNIC

Dayton, Ohio—The annual picnic of the *Dayton* Section was held on June 19th at the Inland Activities Center with an attendance of 92 members and their wives. The picnic informally started at 5:00 P.M. with outdoor games. An excellent dinner was served cafeteria style. Indoor singing and group games were enjoyed after dinner. Soft drinks were served continuously throughout the program. Miss Joyce Kerr, Hauer Music House, entertained with accordion music and led the entire group in a song fest. A bingo game for prizes of cigarettes, clock and some extra special prizes, was also enjoyed.

Announcement was made of the election of the following officers: chairman, W. H. Hobart, Jr.; vice-chairman, Frank Gue; secretary, Richard L. Stratton; treasurer, C. D. Shultheis; board of directors, Charles Brown and Charles O. Adams. Continuing board of directors are: Robert Hous, Carl I. Bertsche, Robert Bowman.

PROJECTION WELDING

Detroit, Mich.—The second special technical meeting of the *Detroit* Section was held on April 27th and was devoted to the subject of Projection Welding. The meeting was held in the Rackham building of the Engineering Society of Detroit and attracted over 80 members and guests with special interest in the subject. It was not necessary to look far for a speaker well equipped to handle the discussion. Larry T. Kendall AWS, of the Master Mechanic's Staff of the Fisher Body Division, GMC, did an outstanding job of completely covering the subject.

With high speed movies, Mr. Kendall showed clearly what happens during the welding process and what the final result is. As the result of such meetings, the Detroit Section is even more convinced that special technical meetings of interest to a limited section of the membership are a necessary and valuable addition to the regular program of general meetings.

NEW OFFICERS INSTALLED BY MADISON SECTION

The Madison Section installed its new officers at the Annual Ladies Night which was attended by 85. Shown here (*left to right*) are: Roy Knudtson, 1st vice-chairman; John Gregory, executive board member; Fred E. Theiler, chairman; Walter Griskavich, executive board member; Howard E. Adkins, executive board member; Harold May, secretary-treasurer; Howard Rasnow, 2nd vice-chairman; and George R. Sell, membership chairman

The presentation of the Membership Charter to the Madison Section. *Left to right:* Howard Adkins, retiring chairman; Roy Knudtson, retiring secretary-treasurer

LADIES NIGHT

Erie, Pa.—The annual ladies night of the *Northwestern Pennsylvania* Section was held on Friday, May 25th at the Erie Elks Club with an attendance of 44 members and guests. Millcreek Guidance Counselor Frank Emmone gave a talk on juvenile delinquency.

IRON-POWDER ELECTRODES

Olean, N. Y.—The April meeting of the *Olean-Bradford* Section, one of the best attended meetings of the year, was held at the Castle Restaurant, Olean, N. Y. on Tuesday, April 24. The speaker who addressed the Section was Donald B. Howard (M'52), supervisor of welding and metallurgy at American Car and Foundry Division, A.C.F. Industries, Berwick, Pa. His subject was "The Evaluation of Iron-Powder Electrodes for Production Use."

After a brief discourse on the general characteristics of iron-powder electrodes, Mr. Howard described in detail the methods adopted for putting such electrodes, from different manufacturers, through their paces. Particular emphasis was made in determining the operating characteristics of the different makes of iron-powder type electrodes under production conditions—ease of deposition, freedom from spatter, welding speed and cost, position of welding, and so on. Welders were given electrodes to try out during this period of evaluation without knowledge of whom the manufacturers were to ensure unbiased comment. Attention was also directed toward assessing the service conditions to which the production welding would be subjected—the minimum allowable elongation under the loading conditions which might be expected, the degree of weld penetration considered necessary, etc. After comparisons had been made in this manner, the electrodes under consideration were graded, according to their performance, into groups describing the service conditions they were felt to be best suited for.

Points of particular interest that came to light during the above process of evaluation were cited by Mr. Howard.

Mr. Howard was kept busy answering questions during the discussion period that followed his talk, and the evening closed with a vote of thanks to him for a most refreshing and interesting talk on what is still a controversial subject.

INERT ARC WELDING

Lewis Run, Pa.—On the 21st of May, at the Valley Hunt Club, members of

OPPORTUNITY for METALLURGISTS

Stoody Company, top manufacturer of hard-facing alloys (as welding electrodes, rods and wires and as alloy castings), needs metallurgists. The positions involve product quality control, research and development, preparation of technical papers and articles, handling of technical correspondence and some field work. Previous experience in the hard-facing field is desirable but not indispensable. Applicants should have a B. S. degree and a thorough working knowledge of welding processes and techniques.

Salary will be commensurate with education and experience. Beside the usual medical benefits and vacations with pay, we have an excellent profit sharing and retirment plan.

The Stoody plant is located near Whittier, a civic minded community of well kept homes, good schools and churches of all faiths. Los Angeles, a leading cultural and entertainment center, is only fourteen miles away. Within short driving distance are 7000 ft. mountains and excellent bathing beaches.

If you feel you can contribute profitable and usable ideas and would like to be a part of an aggressive organization, address a letter to **W. Schumert, General Manager, Box 901, Whittier, California,** giving your qualifications, age, present salary and any other information you think we might want. Correspondence will, of course, be held in strictest confidence.

PAGE offers a line of —the right packaging—the

In ever-increasing numbers, users of welding wire are looking to PAGE for their wire needs. The one biggest reason is that they have found that PAGE—in a unique degree—has the *facilities, experience* and *special skills* to draw and furnish exactly the right wire for your welding jobs. And behind that lies a story.

All Processes Closely Controlled

PAGE is *the one supplier* of welding wire who is in a perfect position to control the chemical and physical properties of its products all the way from billet to rod to finished wire. That is because we purchase our raw materials to rigid specifications; we select heats of carbon, low alloy and stainless steels for certain optimum characteristics—then, upon delivery to the mill, we analyze representative samples for compliance with PAGE specifications.

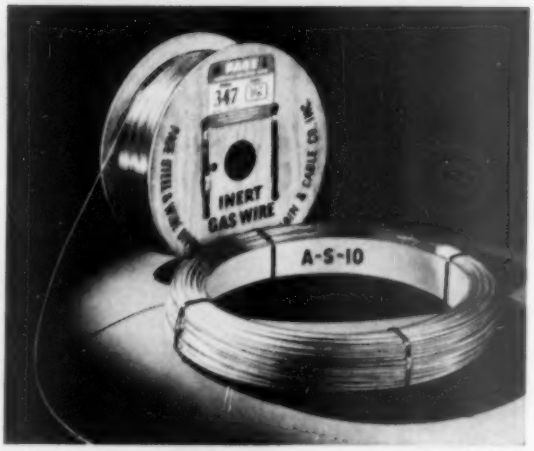
These purchasing and testing practices permit the production of wire capable of depositing weld metal which complies absolutely with welding requirements. *You don't have to compromise* when you buy, specify or use welding wire by PAGE!

Page Meets Today's Needs

One example of PAGE'S facilities for furnishing a wide range of quality-controlled welding wires for modern applications is shown by our stainless steel automatic welding wire. To meet needs of recent developments in the field of inert gas welding, PAGE offers fine wires (.020″ to .09375″) for use in semi-automatic arc welding machines in which the arc is shielded with argon, helium or CO_2 inert gas. These wires, wound on non-returnable plywood reels, furnish the utmost in convenience and freedom of wire feed.

Wire for All Types of Welding

You will find many advantages in standardizing on PAGE welding wire for your needs—whether for automatic or manual use . . . arc or gas welding of all types. Not only does PAGE offer a wide range of analyses, as shown in the column at the right, but we have unsurpassed facilities for manufacturing wire to any desired size, temper or surface finish—and can furnish it promptly, in many methods of packaging, through the convenient nation-wide PAGE Distributor service.



The Right Wire— Wide Analysis Range

There are *26 different analyses* in the PAGE line. These cover the field of applications: heavy automatic submerged arc...light manual submerged . . . inert gas manual . . . automatic, tungsten or metal arc.

AUTOMATIC WELDING WIRE

CARBON STEEL...Any carbon from Armco (.025 max.) to high carbon (.90-1.10)

LOW ALLOYS...All the most popular welding grades.

STAINLESS...All standard AISI grades. Other types on request.

GAS WELDING RODS

Since 1914, the standard of quality, uniformity and satisfactory performance. PAGE offers an exceptionally wide range of rods—furnished in 36-inch lengths, in coils or on reels in the following materials: Mild Steel • Armco • Low Alloy • Carbon Steel • Stainless Steel • Manganese Bronze • Naval Bronze

BARE ELECTRODES

PAGE Bare Electrodes are supplied in any carbon from Armco to high (.90-1.10) carbon.

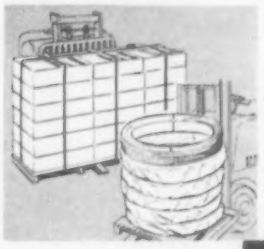
METAL SPRAY WIRE

Furnished as follows: Any carbon from Armco to 1.00 carbon • Low Alloy • Stainless Steel • Manganese Bronze • Naval Bronze

the right welding wires
right service—for modern needs

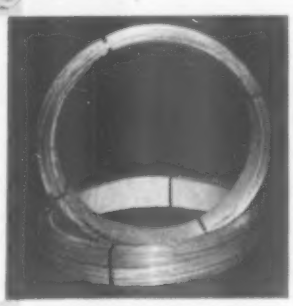
PAGE WIRES ARE PACKAGED RIGHT

PAGE Welding Wires are packaged in a wide variety of ways for the most complete protection and the utmost convenience in handling, in stocking and in use.



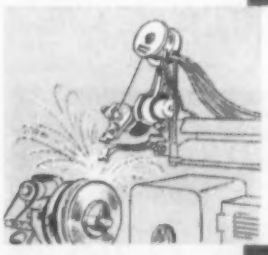
Wrapped Coils and Coils in Cartons

Single and palletized coils, each coil steel-strapped and wrapped in waterproofed paper. ...Also, coils in individual cartons, singly or palletized.



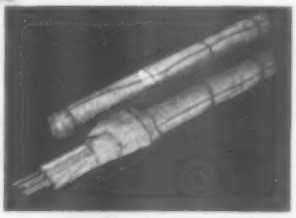
Welding Wire in Coils

PAGE A-S Automatic Welding Wire is regularly furnished in layer wound coils with cardboard liner, four Signode straps to facilitate coiling and easy unwinding.



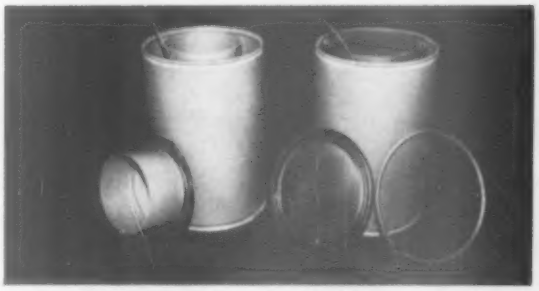
Handy Reels

PAGE Inert Gas Welding Wire is available on reels: Precision thread-wound on twenty-five-pound, non-returnable reels to fit all popular inert gas welding machines.



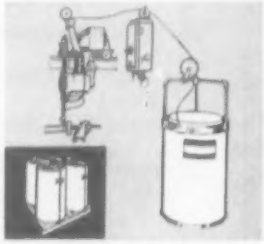
Gas Rod Packing

Gas welding rods are packed in 36" lengths in 50-lb. bundles—paper and burlap wrapped. Also in coils and reels (approx. 150 lbs.)—burlap wrapped. Stainless rods also come in 10-lb. fibreboard cartons.



LEFT: Pay-off-pak ready for filling, with "wire slinger" for uncoiling at extreme left. RIGHT: "Wire slinger" installed for feeding out wire; also, below, re-usable lid and retaining ring. Ring insures smooth feed-out of wire without snarls or kinks.

Sketch at right shows Pay-off-pak for continuous feeding up to 500 lbs. of wire without rethreading. Also (inset) lightweight Leverpaks. Both these containers protect against coil distortion... are easily opened, resealed, handled, stored.



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Aircomatic Aluminum Welding Wires Aircomatic Titanium Welding Wires (Not stocked) Aircomatic Magnesium Welding Wires	supplied in 10 pound expendable spools.
Aircomatic Stainless Steel Welding Wires Aircomatic Nickel Welding Wires (Limited stock) Aircomatic Copper and Copper Base Alloy Welding Wires	supplied in 25 pound expendable spools.
Aircomatic Steel Welding Wires	supplied in 25-pound expendable spools, 60-pound chip board cores, 100- to 150-pound catch weight coils, 250- and 500-pound Wirepak drums.

All welding wires supplied by Airco for automatic Heliwelding and Aircomatic welding meet rigidly controlled specifications as to chemical analysis, surface finish, cleanliness as well as packaging. If any technical or metallurgical information is needed, your nearby Airco representative will be glad to assist you.

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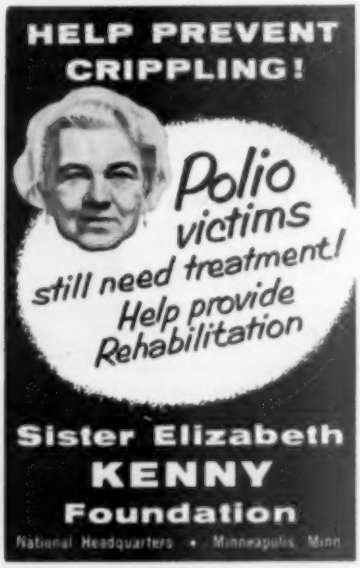
the *Olean-Bradford* Section enjoyed an interesting program, on "Inert-Arc Welding—Advantages, Disadvantages and Applications," as covered by W. T. Davis, process representative for Air Reduction Sales Co.

Mr. Davis illustrated the new usage and the procedures of the increasingly important inert-arc welding process. Mr. Davis' address was enthusiastically received by the members and guests present.

TOWNSEND HONORED

The *Santa Clara Valley* Section Achievement Award is being presented to Ray L. Townsend, Tweco Products Co. by outgoing chairman, Wallace J. Erichsen Westinghouse Electric Corp. Presentation was made at the annual May meeting dinner dance held at the Almaden Country Club, Los Gatos, Calif., in recognition of Mr. Townsend's contribution at both the national and local level in fostering activity in the American Welding Society.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New Members

Effective July 1, 1956

MEMBERSHIP CLASSIFICATION

A—Sustaining Member B—Member C—Associate Member

D—Student E—Honorary Member F—Life Member

Total National Membership July 1, 1956

Sustaining Members	128
Members	5,525
Associate Members	5,866
Students	158
Honorary Members	9
Life Members	15
Total	11,701

AWS—A Storehouse of Welding Knowledge

ARIZONA

Hayes, Art (C)

BIRMINGHAM

Thigpen, Lane F. (B)

BOSTON

Burke, John J. (C)
Coletti, Guy (B)
Depper, Murray (B)
Pekin, Jacob A. (B)

CHICAGO

Dymon, Henry (C)
Jaso, Jack (C)
Fothergill, Gordon K. (B)
Murphy, Edward S. (B)
Stamos, Chris (B)
Steen, William H. (B)

CINCINNATI

Campbell, Taft (C)
Etingher, Constantin (C)
Hegel, Louys G. (C)
Kroger, Robert C. (C)
Lynn, Robert W. (C)
Mecklenborg, L. W. (C)
Rhodes, Utus J. (B)
Schmidt, Gustau E. (C)
Schueler, Arthur W. (C)

CLEVELAND

Debicki, Alfred F., Jr. (B)
McDowell, Robert C. (A)

COLUMBUS

Barrett, Larry (D)
Hamad, M. Fawzi (D)
Hamilton, William A. (D)
Heckler, Harry J. (D)
Hickox, George K. (D)
Thompson, H. B. (C)

DAYTON

Todoroff, Nick (C)

DETROIT

Bann, Michael (C)
Blatt, Leland F. (B)
Drummond, Burton J. (B)
James, Curtis A. (B)
Lohrber, Albert E. (B)
Miller, Arthur (B)
Patel, Bhasker T. (C)
Tabor, Ralph L. (B)
Wing, J. Willis (B)

HOUSTON

Anderson, Robert Clark (B)
Craig, B. J. (C)
Flake, Jack M. L. (B)
Guidry, George L. (C)
Martin, William A. (B)
Palmer, William Earl (C)
Porter, H. P. (B)
Sandberg, John H. (B)

FOX VALLEY

Kunz, Arno K. (C)

INDIANA

Pollard, Grant F. (C)

IOWA-ILLINOIS

Castle, Clarence R. (C)

LONG ISLAND

Nilsson, Paul G. (C)

LOS ANGELES

Bowman, Bernard (C)
Fish, Robert E. (C)
Foley, John L. (B)
Fullington, Forrest R. (C)
Pasley, L. G. (C)
Seagren, Wayne L. (C)
Troup, George A. (C)
Warner, Robert E. (C)

MILWAUKEE

Elsen, John M. (C)

MAHONING VALLEY

Entrikin, R. F. (B)
Hubbard, Louis (C)

MICHIANA

Holden, William Russell (B)

NEBRASKA

Hohnstein, Paul (B)
Rickels, John H. (B)
Schafer, N. J. (C)

NEW JERSEY

Defoe, Jonathan C. (C)
Maffei, Charles (B)
Wells, Arthur (C)

NEW ORLEANS

Tanguis, Larry W. (C)

NEW YORK

Barstow, Vladimir (B)
Landauer, Paul J. (B)
Nathan, Alfred T. (C)

NIAGARA FRONTIER

Hislop, R. G. (B)
Taylor, R. Erie (C)

NORTH CENTRAL OHIO

Bouma, James A. (B)
Margraf, Burton D. (C)

NORTHWEST

Brower, Robert W. (B)

NORTHWESTERN PA.

Chimenti, Frank A. (D)

PEORIA

Osborne, E. C. (C)

PHILADELPHIA

Hammond, H. S. (B)
Imburgia, Albert A. (B)
Mehaffey, James A. (B)

PITTSBURGH

Amato, Sam J. (C)
Jessee, Jack (B)

PUGET SOUND

Galbreath, John O. (C)
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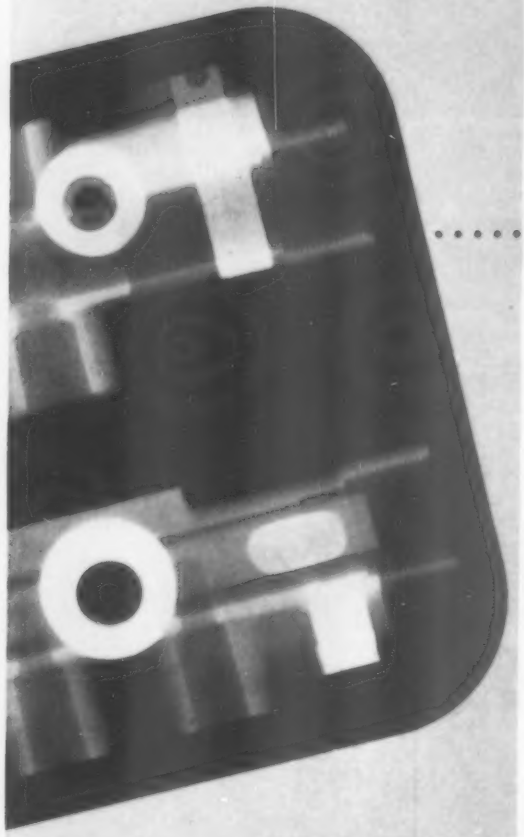

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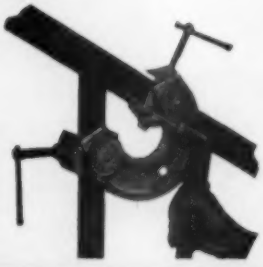

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ABSTRACTS OF CURRENT PATENTS

prepared by Vern L. Oldham

Printed copies of patents may be obtained for 25¢ from the Commissioner of Patents, Washington, D. C.

2,748,528—Welded Fluorescent Lamp Base Pins—Warren F. Albrecht, Euclid, Ohio, assignor to General Electric Co., a corporation of New York.

This patented electric device includes a lead wire having a base including an elongated tubular contact pin. A lead wire is threaded through the bore of the pin and is welded into the end of the pin by a weld junction forming an end wall completely closing one end of the pin. The major part of the fused metal in the weld junction is from the pin.

2,749,866—Manufacturer of Metal Tubes Applicable in Some Cases as Electric Conductors or Other Parts of Electric Cables—Henry Johnson Dixon, West Kirkby, and George Harry Webster, Broadgreen, Liverpool, England, assignors to British Insulated Callender's Cables Ltd., London, England, a British company.

This patent is on a process for the production of a continuous seam in the wall of a long length of tubing by a brazing or soldering action. The method comprises twice heating elemental lengths of tubing to the seaming temperature by passing the tube through two heating zones in succession, each zone of which when it has reached normal operating temperature and the tubing is running at normal speed is capable of locally heating the tubing to the seaming temperature. The elemental lengths of tubing are cooled after passing them through each heating zone and the time between the passage of the elemental lengths through the two heating zones is adjusted by spacing such zones apart a distance at least equal to the aggregate length of tubing leaving the first zone in an unseamed condition due to a stoppage and to a restart and return to normal running speed following such stoppage.

2,750,484—Uniform Pressure Resistance Welding Apparatus—Lux H. Ewald, New York, N. Y.

Ewald's patent is on a spot-welding head including a frame, a welding arm reciprocally mounted on the frame and a pressure arm pivotally supported on the frame. A leaf spring is connected between the pressure arm and the welding arm while a fulcrum member is carried by the pressure arm and is adapted to bear against the spring in a predetermined position according to the welding pressure to be applied through such welding arm.

2,750,485—Electrode Holder and Eye Shield Combination for Electric Welding—Louis Kun, Jr., Louis Kun, Sr., and Zoltan Dan, Lorain, Ohio.

This is a patent upon a specialized welding electrode holder of the type indicated.

2,750,592—Welding Mask—Jouko B. Salminen, Leicester, Mass.

A novel welding mask is shown in this patent and covers the usual head harness and hood hingedly connected to the harness. The feature of the mask relates to the use of a transparent guard hingedly attached within the hood to the lower portion thereof for protection of the welder's face when the hood is in a slightly raised position.

2,750,593—Welding Helmet Face Shield—Frederick M. Bowers, Nether Providence Township, Delaware County, Pa., assignor to The Fibre Metal Products Co., Chester, Pa., a corporation of Pennsylvania.

The patented face shield and welding helmet is made of Fiberglas bonded to polyester resin. A feature of the helmet relates to the provision of a fine wire metal screen embedded in a face portion of the mask and with portions of the wire screen being exposed to engage sparks from a welding operation and dissipate heat throughout the screen.

2,750,911—Rotatable Expansible Welding Fixture—Reuben C. Baker, Coalinga, and Thomas M. Ragan, Downey, Calif., assignors to Baker Oil Tools, Inc., Vernon, Calif., a corporation of California.

A patented expansible welding fixture for special action is disclosed in and covered by this patent.

2,751,478—Welding Composition—Clarence E. Jackson and Arthur E. Shrubsall, Niagara Falls, N. Y., assignors to Union Carbide and Carbon Corp., a corporation of New York.

This patent relates to a welding process of the submerged-arc type wherein a blanket of silicon-containing welding medium covers the welding region of the workpiece. In the process, the weld metal is enriched in molybdenum and chromium content by incorporating oxides of such materials in the welding medium.

2,751,479—Method and Means for Induction Welding—John V. Cowan, Danbury, Conn., assignor to Sperry Products, Inc., Danbury, Conn., a corporation of New York.

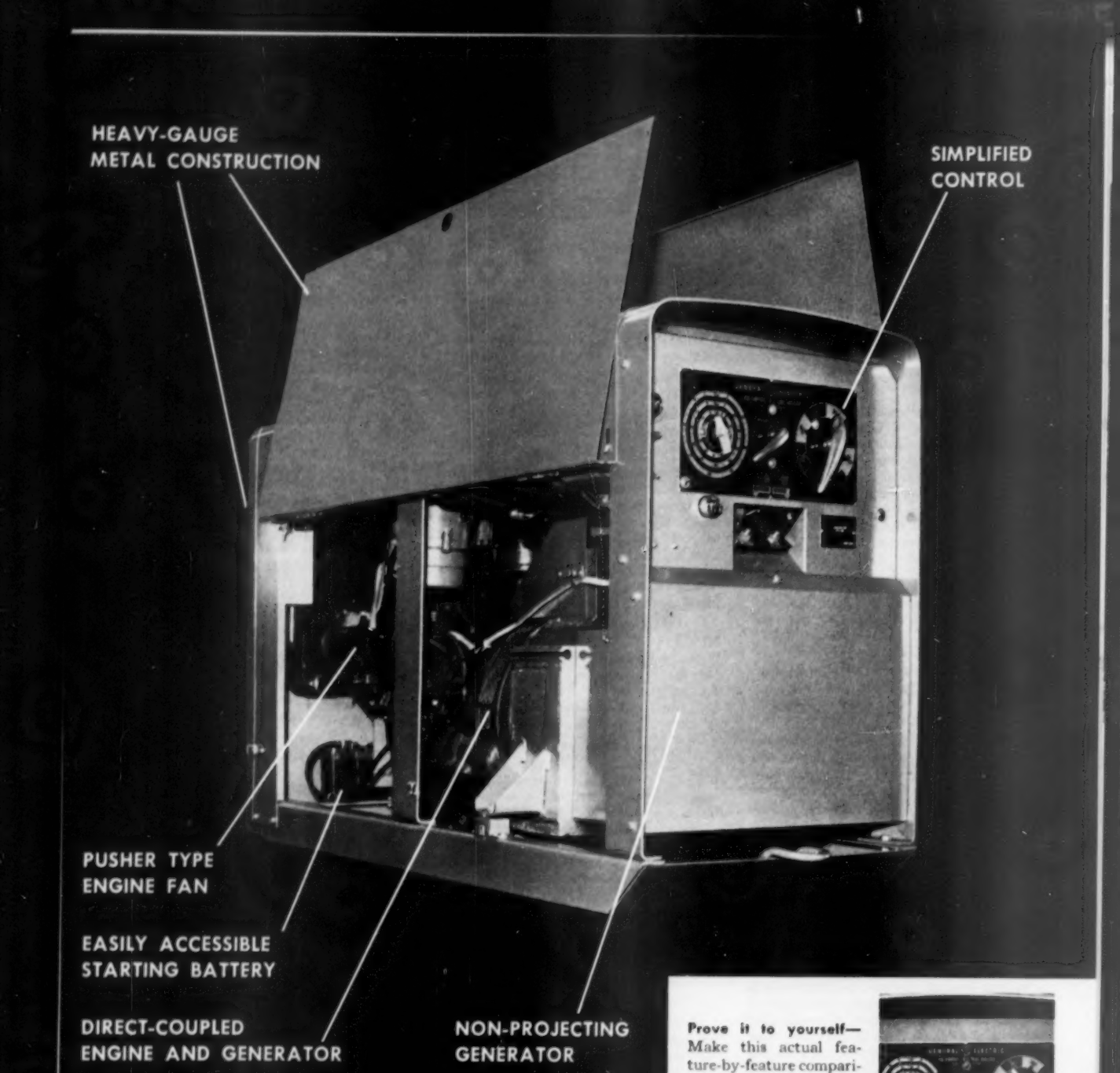
This method relates to the inductive welding of parts of relatively large cross-sectional areas in which the outer portions normally tend to heat up faster than the inner portions. The method comprises the positioning of an auxiliary member of the same material and cross section between the parts to be welded together, and heating the auxiliary member inductively. The heat from the outer portion of the auxiliary member is conducted to the parts to be welded together and the inner portion of the auxiliary member is insulated against heat transfer to the parts prior to the welding push-up. After the outer portion of the auxiliary member has reached the welding temperature, the parts and auxiliary member are pushed together so that the inner portion of the auxiliary member will transfer its heat to the inner portion of the parts to be welded.

2,751,482—Cutting and Gouging Torches and Electrodes Therefore—Myron Davis Stepath, Bremerton, Wash.

This patent relates to electric arc apparatus comprising an electrode in the form of an elongated conductive rod having on one side thereof means forming an open-sided gas channel extending the length of the rod. An electrode holder means comprising an electrode supporting member provides a seat for the channeled side of the electrode rod and a clamp member presses upon the electrode rod and urges it into its seat. Gas jet orifice means are provided in the holder means adjacent the electrode rod seat and are disposed for directing a high velocity stream of gas in and along the gas channel toward the end of the electrode rod that projects from the holder.

2,752,412—Welding Cable Winding—Frederick Wreford and John S. Wreford, Detroit, Mich., Annie A. M. Wreford, executrix of the estate of said Frederick S. Wreford, deceased, assignors to Gar Wood Industries, Inc., Wayne, Mich., a corporation of Michigan.

A flexible electric welding cable winding is disclosed in and covered by this patent. The winding includes a tubular casing of flexible insulating material having a single tubular welding current conductor insulator of approximately semicircular cross section loosely and relatively slidably mounted within and extending end to end of the casing. A pair of flexible electric welding current conductors are disposed side by side within the casing with a semicircular cross section of the



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For more information about how General Electric engine-driven welders can help you, contact your nearby General Electric Welding Distributor. He is listed in the yellow pages of your telephone book. Write for descriptive bulletin to Section 714-5A, General Electric Company, Schenectady 5, New York.

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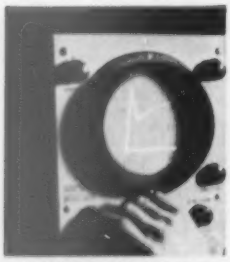

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G-E 295-amp AC welders help Side-O-Matic Unloader Corporation fabricate truck-mounted concrete-block unloaders. Fabrication process requires welds on materials as heavy as 8-inch channel.

Low-cost General Electric 295-amp Welders Pay Off on Two Big-welder Jobs

High open-circuit voltage of General Electric 295-amp AC welders allows York-Shipley, Inc. to use required low-hydrogen electrodes with almost complete freedom from popouts—speeds production of heating-unit generators.

Production welding applications at two manufacturing plants in York, Pennsylvania again show how General Electric 295-amp AC general purpose welders deliver big-welder performance for the initial cost of the light-duty welder.

York-Shipley, Inc., a major manufacturer of heating and air conditioning equipment, uses G-E 295-amp AC welders in fabricating heating-unit generators for their oil and gas-fired residential furnaces.

Glenn C. Himes, production supervisor, reports, "In fabricating our heating-unit generators we have to use low-hydrogen electrodes to weld 'sandwiches' of mild steel, aluminized steel, and stainless steel. The high open circuit voltage of the G-E welders allows us to use low-hydrogen electrodes with almost complete freedom from popouts—something other machines we've tried couldn't manage."

Side-O-Matic Unloader Corporation, manufacturers of truck-mounted concrete-block unloaders, uses G-E welders exclusively in its manufacturing process.

Ralph Sheasley, shop supervisor for Side-O-Matic, says, "Our G-E 295-amp welders do a good job—under almost continuous operation. Fabricating our unloaders takes a variety of different welds on material as heavy as 8-inch channel. We get the high-quality, strong welds we need with these G-E welders."

See for yourself how G-E 295-amp AC welders can do big-welder jobs. Contact your nearby General Electric Welding Distributor (He's listed in the yellow pages of your phone book) or write for descriptive bulletin GEC-1305, Sect. 712-3, General Electric Company, Schenectady 5, N. Y.

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tubular insulator lying between the two current conductors. Each of these current conductors is composed of loosely packed multiple strands of small wires separated from one another by minute interstices forming passages for cooling liquid.

2,752,467—Measuring and/or Control Installation for Electric Welding—Richard Peretz, Ixelles, Belgium, assignor to Societe Anonyme "Electromecanique," Anderlecht (Brussels), Belgium.

This patent is on electric resistance welding machines comprising two arms for bearing the welding electrodes, and a saturable closed magnetic core is situated in the magnetic field generated by the flow of welding current. It is disposed on one side of one of the arms. At least two windings are wound on the core in such a manner as not to induce an electromotive force at the exterior of the whole formed by the core and the windings on it. This core and windings are positioned in such a manner that the magnetic circuit presented to the induction flux generated by the welding current is formed substantially by air. An oscillator generating electric oscillations of a frequency of higher than that of the welding current feeds such oscillations to the windings. A resistance is connected in series with the oscillator and windings, and a rectifier is connected in shunt on the terminals of the resistance for giving the mean value of the rectified tension generated between the terminals of the resistance. The characteristics of the members present in the machine are such that the rectified value of the alternating current which flows through the two windings referred to before is a quadratic response to the welding current.

2,752,468—Apparatus for Field Welding Seams in Horizontal Plate—Robert B. Costello, Rahway, N. J., assignor to the M. W. Kellogg Co., Jersey City, N. J., a corporation of Delaware.

This patent to Costello relates to apparatus for electric arc welding horizontal seams between superimposed upstanding elements. The apparatus includes a support movable relatively along a horizontal seam between superimposed upstanding elements and means movable with the support and adapted to supply a welding electrode for discharge of electric current to the seam. An endless deformable member is carried by the support and is positioned against the surface of the lower one of the elements adjacent to the seam, while means mount the endless member for gyratory movement about a vertically disposed axis to carry the peripheral portion of the endless member through a substantially horizontally disposed circular path. Other means, including those for depositing flux on the weld seam zone, are included in the apparatus.

2,752,469—Automatic Welder—Robert W. Price, East Aurora, N. Y., assignor to Westinghouse Electric Corp., East Pittsburgh, Pa., a corporation of Pennsylvania.

Price's patent upon an automatic arc welder includes means for impressing potential between a consumable weld rod and the work. Means for moving the rod toward and away from the work are provided while start means are present for rendering effective potential impressing means and the moving means to operate to produce welds. Stop means are provided for rendering effective the moving means to move the rod away from the work. The potential impressing means remain effective for a predetermined interval of time and thereafter the moving means and the potential impressing means are rendered ineffective.

2,752,873—Method and Apparatus for Feeding and Forming Sheet Strip Stock Into a Helix—Jonathan Roy Freeze, Middletown, Ohio, assignor to Armco Steel Corp., Middletown, Ohio, a corporation of Ohio.

This patent relates to a method and apparatus for making the spiral welded pipe from metal stock and includes the step of forming the stock into a helix with substantially meeting stock edges. The relative radial position of the substantially meeting edges are continuously adjusted with regard to the pipe axis in accordance with the camber of the strip, and the edges are continuously welded in their adjusted relative positions.

2,753,425—Welding Machine—John J. Flood, West Medway, and Clifton E. Thompson, Lawrence, Mass.

This patent is on a welding machine including a carriage adapted to move along the path of weld and having a frame mounted thereon. This frame includes drive rollers for feeding a wire toward the weld. A welding head including a welding barrel and nozzle is provided, and a flexible casing connects the frame and the welding nozzle. Electrical control means are provided to control wire feed and for controlling flow of an inert gas through the flexible casing.

2,753,426—Porous Shielding Body to Be Used While Fastening Pins, Studs and the Like By Means of Arc Welding or Soldering and Method for Producing Same—Karl J. Aversten, Lidingo, Sweden, assignor to Svenska Aktiebolaget Gasaccumulator, Lidingo (near Stockholm), Sweden, a corporation of Sweden.

This patent is on a porous shielding body for arc welding with studs. The article comprises a glass fiber body having a central opening. This opening is larger than the stud with which the body is to be used so that the glass fiber is adapted to form a shield in arc welding action.

2,753,427—Gas-Shielded Metal-Arc Welding—Donald M. Yenni, Williamsville, and Kenneth L. Thomas, Kenmore, N. Y., assignors to Union Carbide and Carbon Corp., a corporation of New York.

The present patent is on a shielding gas for direct-current, reverse-polarity, sigma welding of carbon steel. The new gas

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2,753,428—Method and Apparatus for Butt Welding Pipe Sections—Lattrell Graham, Amarillo, Tex.

Graham's patent relates to welding together beveled ends of pipe sections. The new process relates to steps of holding the pipe section ends together to form a V-shaped groove extending around the pipe sections and confining a ring of welding material in the groove. The ring is insulated from the groove with flux material. Welding current is applied to the ring section to effect initial fusing of portions thereof to start an arc to cause the flux material to melt and effect fusing of the welding material. The application of welding current is continued until the welding ring is at least partially melted into contact with the V-shaped groove.

2,753,429—Electrical Discharge Machining—Ian C. McKechnie, Pontiac, Mich., assignor to Elox Corporation of Michigan, Clawson, Mich.

This apparatus relates to the machining by electrical discharge action of a conductive workpiece. The apparatus includes an electrode, a head and other means for reciprocating the electrode. Means connect the electrode and the workpiece to an a-c source for effecting electrical discharge between the electrode and the workpiece. The means for reciprocating the electrode are also provided with electrical control and actuating means therefore.

2,753,562—Welding Hood with Hard Hat—Warren Sand McDonald, Redwood City, Calif., assignor to the Robert L. Johnson Corp., Redwood City, Calif.

This patented welder's helmet comprises a hard hat section having a protecting mask pivotally connected in the helmet and movable with relation to the hard hat section.

2,753,623—Solid Phase Bonding of Metals—Helmich W. Boessenkool, South Easton, and George Durst and Sidney Siegel, Attleboro, Mass., assignors to Metals & Controls Corp., Attleboro, Mass., a corporation of Massachusetts.

This patent is on a method of solid-phase bonding malleable metals in accordance with the characteristic solid-phase bonding curve which expresses the minimum squeezing deformations required at various temperatures of at least one of the metals, as the metals enter the squeezing step. In general, the patent relates to the pressure bonding of metals and wherein sintering and heating actions are also used.

2,753,680—Method for Manufacturing Chain Links Having an Integral Stud—Charles D. Linnenbank, Chester, Pa., assignor to Baldt Anchor, Chain and Forge Division of the Boston Metals Co., Chester, Pa., a corporation of Maryland.

Linnenbank's patent relates to a specialized process for forming chain links by welding and forging actions on a pair of generally U-shaped link segments wherein the ends of the link segments are initially butted for the securing action desired.

2,753,826—Machine for Manufacture of Tanks and Vessels—Paul S. Dougherty, La Grange, Ill., assignor to Metal Coating Corp., a corporation of Illinois.

This novel machine includes axially aligned, opposed rotatable work holders, each of which has means thereon for holding an end closure for a vessel. Other means are provided for supporting a vessel shell between and apart from the work holders, one of which can move toward the other to bring the three components of the vessel together. Welding head means are provided for welding the junctures of the three vessel sections together and for rotating the assembled vessels for the welding action.

2,754,200—Alloy Weld Rods—Arthur T. Cape, Los Angeles, Calif., assignor to Coast Metals, Inc., Little Ferry, N. J., a corporation of Delaware.

This patent is on an alloy weld rod containing about 25% molybdenum, about 3.4% boron, about 2% copper, about 2% chromium, and about 1.75% carbon. The balance in the rod is substantially all iron.

2,754,393—Electrical Contact and Method of Making Same—Verne Clair, Jr., Levittown, N. Y., assignor to Koldweld Corp., New York, N. Y., a corporation of New York.

This patent is on an electric contact consisting of a contact member having a depression on one side and a hollow pressure-hardened integral contact projecting from the member opposite to the depression. This contact is capped by a layer of different contact metal firmly bonded thereto by a solid phase, cold weld joint.

2,754,394—Apparatus for Spot Welding of Thin Metals—Marvin S. Weinstein, Washington, D. C.

This patent is on an apparatus for use with a normally open condenser discharge circuit for welding strips of thin metal to form webbed structural members. The apparatus includes special control cams and other members for moving spot welding rods into engagement with the workpieces and effecting desires pressures thereon prior to and during welding action.

2,754,395—Inert-Gas Shielded-Arc Welding Torch—Arthur P. Scheller, Chatham, and Edward R. Behnke, Parsippany, N. J., assignors to Union Carbide and Carbon Corp., a corporation of New York.

This patent is on a gas-shielded arc-welding torch including a current and gas supplying head, an electrode holder in the head and a gas directing nozzle adjacent the lower end of the holder. An electrode contactor tube is held by a collet in the torch and is separately removable for repair or replacement when the collet is in a released position.

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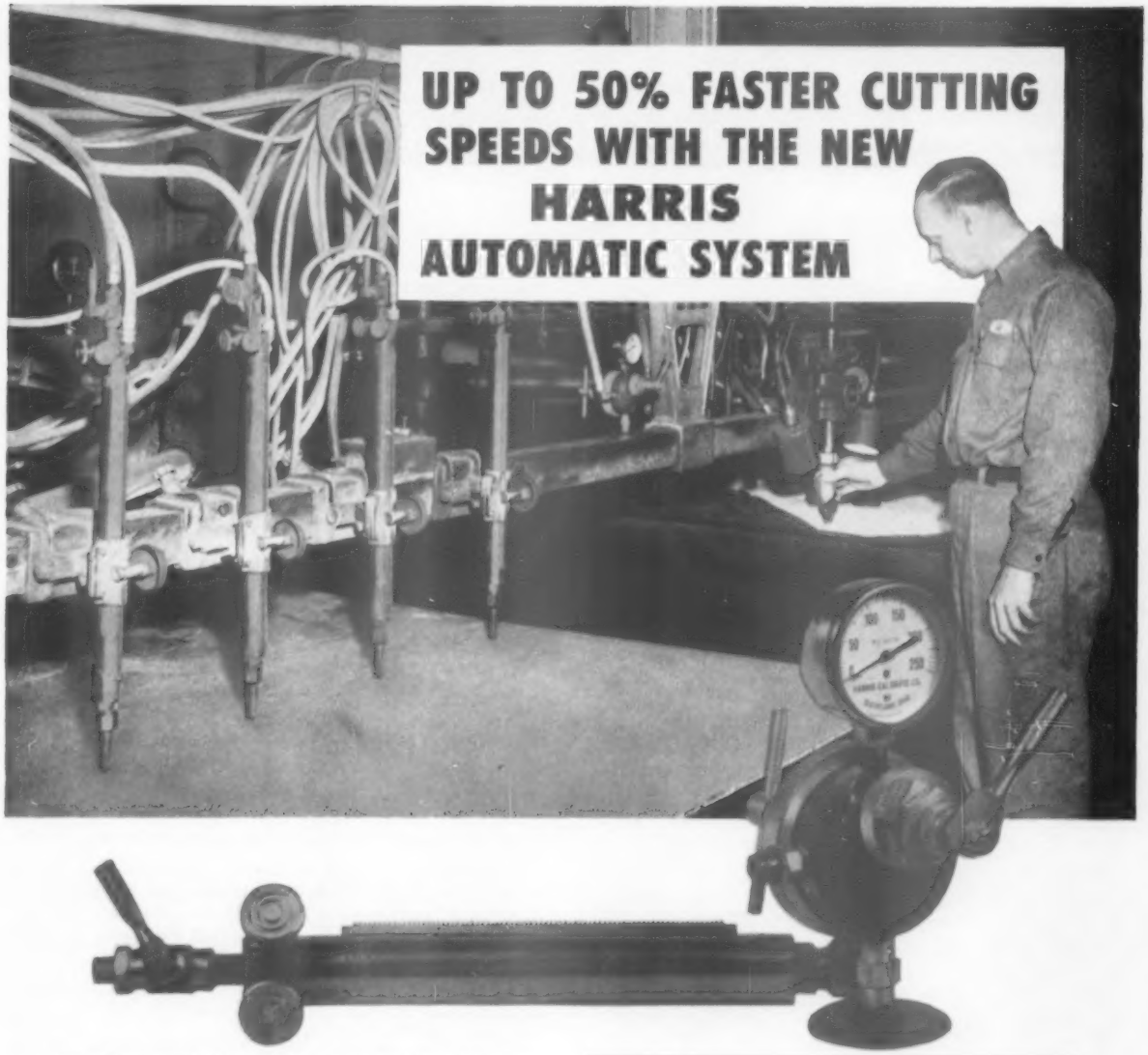

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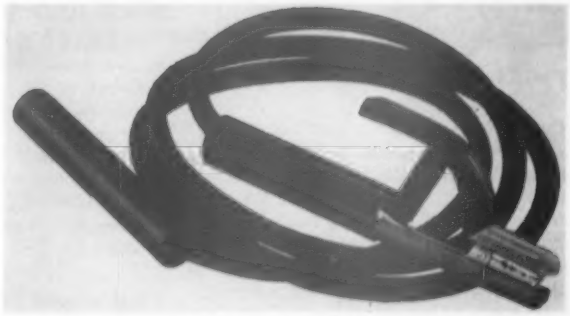
For complete information on new aluminum welding cable, contact your welding equipment manufacturer or your nearby welding supply distributor. Aluminum welding cable is produced for equipment manufacturers by Kaiser Aluminum at the company's Newark, Ohio wire and cable mill.



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PERSONNEL

Orden Appointed Latin-American Representative

David Birger Orden has been named Latin-American representative by Metal & Thermit Corp., New York. His headquarters will be in Mexico City. Mr. Orden has spent several years in Latin America.

A native of Copenhagen, Denmark, Mr. Orden received the degree of Bachelor of Commercial Science at

David B. Orden

Copenhagen and later undertook graduate study in Foreign Trade and Business Administration at Meuchatel and Geneva, Switzerland. He is an associate member of the AMERICAN WELDING SOCIETY.

Briggs Made Western Manager

Harris Calorific, Cleveland, announces the appointment of Gordon L. Briggs as western manager. He will supervise sales in Oregon, Washington and California, while making his home at E. 7107 Broadway, Route 9, Spokane, Wash.

Nunley Promoted

Lee Nunley has recently been promoted to the position of assistant to the president of the Dye Oxygen Co., Inc., Phoenix, Aria.

Mr. Nunley has been associated with Dye Oxygen Co. for three and one half years, and immediately prior to this promotion held the post of purchasing agent. He is a member of the AMERICAN WELDING SOCIETY, Purchasing Agents Assn., and the Phoenix Junior Chamber of Commerce.

Marshall Appointed by Drawalloy

E. J. Brady, president, Drawalloy Corp., announced recently the appointment of Bond Marshall to the position of manager of Field Engineering. Mr. Marshall will specialize in the application and development of automatic and

Bond Marshall

seminautomatic hard-surfacing wires in conjunction with the company's newly announced line of fabricated hard-surfacing wires.

Mr. Marshall is a graduate of Carnegie Institute of Technology with a B.S. in Metallurgical Engineering. He is a member of the AMERICAN WELDING SOCIETY.

Cloues and Cameron Appointed

The Pittsburgh Bridge & Iron Works announce the appointment of R. W. Cloues to the position of chief engineer, and H. R. Cameron to the position of consulting engineer, effective immediately.

Both Mr. Cloues and Mr. Cameron are members of the AMERICAN WELDING SOCIETY.

Kreifeldt Made Sales Manager

Henry W. Kreifeldt has been appointed sales manager of the Morton Manufacturing Co., Muskegon Heights, Mich.

Mr. Kreifeldt joined Morton in 1935 as a draftsman, later becoming a design engineer of special machine tools. In 1951 he transferred to the Sales Department from the Engineering Department where he has served until the present as a sales engineer of both Machine Tools, and Special Machinery and Automatic Welding Machinery.

Nordin Made Regional Manager

Robert Nordin, has been appointed regional manager for All-State Welding Alloys Co., Inc., to cover the Southern

Robert Nordin

Gulf States (Louisiana, Mississippi, East Texas, Southern Alabama and the Panhandle of Florida).

Mr. Nordin will be responsible for sales and service to the users and distributors of All-State alloys and fluxes in his area.

A member of the AMERICAN WELDING SOCIETY, Mr. Nordin has devoted his particular attention to the specialty welding field since graduating, in 1943, from the U. S. Maritime Engineering School, Sheepshead Bay, N. Y. He joined All-State in July 1954.

Lutes and Marini Promoted

Effective July 1, 1956, E. B. Lutes and L. G. Marini were elected vice-presidents, engineering and production, respectively, of Arcrods Corp., Sparrows Point, Md.

Mr. Lutes served as chief inspector, research and development engineer, and welding engineer since he joined Arcrods in 1939. He is an active member of the AMERICAN WELDING SOCIETY and is a past chairman of the Maryland Section of AWS.

Mr. Marini has been actively en-

gaged in various management capacities in the welding industry since 1939. He joined Arcrods in 1946. He, also, is an active member of the AMERICAN WELDING SOCIETY.

Vreeland Appointed to New Sales Post

John J. Vreeland, previously a products control head and technical service metallurgist at the Cleveland, Ohio, mill of Chase Brass & Copper Co. has been named staff manager, sheet and strip, at the firm's Waterbury, Conn., headquarters.

A New Englander by birth, Mr. Vreeland graduated from Rensselaer Polytechnic Institute as a chemical engineer and was an instructor there for a number of years prior to his joining Chase in 1930 as research engineer. His past experience with Chase covered the fields of sales promotion and metallurgical engineering, both in Waterbury and at the Ohio mills.

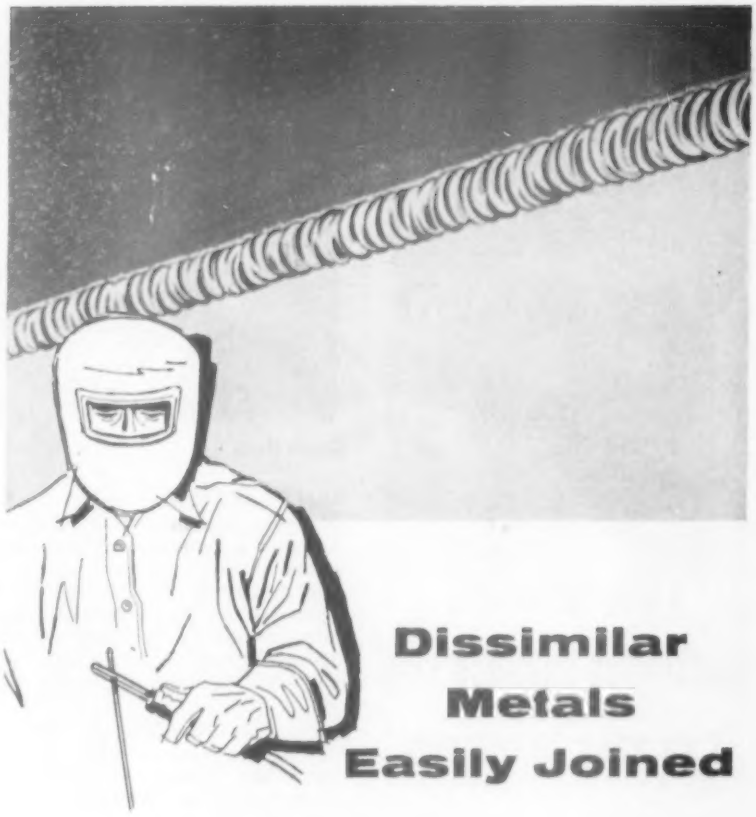
He is a member of the American Society for Metals, AMERICAN WELDING SOCIETY of which he was past chairman in the Hartford Section, and American Society for Testing Materials.

Kaufman and Helm Elected to Board

Fred A. Kaufman, vice-president in charge of manufacturing and sales, and Dr. David Helm, vice-president in charge of research, have been elected directors of The McKay Co., Pittsburgh 22, Pa., Mr. Kaufman was also elected to the board of Surface Chemicals, Inc., a wholly owned subsidiary of McKay.

Mr. Kaufman, who has been with McKay for 13 years, is a graduate metallurgical engineer, and joined the company following operations and research positions with Carnegie Illinois

Fred A. Kaufman



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David Helm

Steel Co. and Crown Can Co. He has been successively a fellow of the McKay Research Fellowship at Mellon Institute of Industrial Research; manager of Technical Service, Research and Quality Control at McKay's York, Pa., plant; sales manager of his company's welding electrode division in Pittsburgh; general sales manager; and, since 1954, vice-president.

Dr. Helm joined McKay as the company's first research fellow in 1936, when the McKay Fellowship was started at Mellon Institute. He is a graduate of Denison University, obtaining his master's degree from Michigan State College, and his doctorate from Ohio State University. Following his graduation from Ohio State, Dr. Helm was employed as a metallurgical research engineer at Ohio State's Engineering Experiment Station, and later as research chemist at the Midgley Foundation. He will continue as vice-president of Research, with headquarters at Mellon Institute.

Mr. Kaufman and Dr. Helm are members of the AMERICAN WELDING SOCIETY.

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De Leo Appointed Engineering Consultant

Progressive Welder Sales Company of Detroit announces the appointment of Peter D. De Leo as engineering consultant.

Mr. De Leo joined the Company in 1945 as head of the Experimental Department and has for some years been chief electrical engineer. Prior to 1945 he was associated with Western Electric Co. and Carnegie-Illinois Steel Co. He received his engineering degree from Purdue University and completed his Master's degree at the University of Pittsburgh.

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Wilson Retires

James M. Wilson, for 39 years a field engineer attached to the Pittsburgh, Pa., office of Metal & Thermit Corp., retired as of June 30, 1956. He will continue as a consultant to M & T until the end of the year, the company announced.

James M. Wilson

In the course of his long service with Metal & Thermit, Mr. Wilson pioneered many of the heavier applications of thermit welding. Joining M & T in 1917 when the company opened its Pittsburgh branch office, he took his early training under H. D. Kelley on heavy steel mill welds, and as a result of his technical knowledge of thermit welding, gradually extended the use of the process to many other industries.

Mr. Wilson was born in Lanarkshire, Scotland, in 1891, and came to Pittsburgh in 1909. His first job was with the Pennsylvania Railroad where he did thermit welding of locomotive frames, his initial introduction to the process. Later he was in charge of heat treating in the forge department of Westinghouse.

He graduated from Carnegie Institute of Technology in 1917, majoring in forging and heat treatment of steel.

Mr. Wilson is a member of the American Welding Society.

BOUND VOLUMES OF 1955 JOURNAL NOW AVAILABLE

Bound Volumes of The Welding Journal for the year 1955 are available in black imitation leather covers, together with a comprehensive subject and authors index. Price $15, including postage. Copies may be ordered through the American Welding Society, 33 W. 39th St., New York 18, N. Y.

OBITUARY

H. C. Boardman, Past-President of American Welding Society, Dies

Henry Clow Boardman, director of research, Chicago Bridge and Iron Co., Chicago, Ill., died on August 6th in Chicago.

Mr. Boardman was born in Plainfield, Ill., on Apr. 29, 1887. He was graduated from the University of Illinois in 1910. He received his Civil Engineering Degree from the University of Illinois and holds an honorary Doctor of Engineering Degree from the South Dakota State School of Mines.

Entering the army as a private in 1916 he was discharged in 1919 as a major in the Field Artillery. Following the war he was in business in Kansas City and was an instructor at the University of Illinois. From 1910 to 1916 and since 1926 he has been with the Chicago Bridge & Iron Co.

In 1929, he served as president of the American Welding Society, and in 1950, he was made chairman of the Welding Research Council. Since 1954, Mr. Boardman has been chairman of the Boiler and Pressure Vessel Code Committee of the American Society of Mechanical Engineers. He was a member of this committee for over twenty years and served on many of its important subcommittees. He was also active in the American Society of Civil Engineers, the American Petroleum Institute, the Western Society of Engineers, the American Society of Metals, the American Society for Testing Materials, the American Water Works Association and the American Association for Advancement of Science. In addition, he was a member of Tau Beta Pi and Sigma Xi.

H. C. Boardman

On May 27, 1923, Mr. Boardman was married to Bessie McCumber, who survives him. He is also survived by three sisters and a brother.

A Friend Passes On

About a year and a half ago, a short terse note from Henry Clow Boardman informed and shocked the Engineering Societies' Headquarters that a malignant condition spreading to his hip bones made it desirable for him to resign from the chairmanship of the ASME Boiler Code Committee, the Pressure Vessel Research Committee, the Welding Research Council and several other committees. Practically all of these important groups respectfully requested Harry to reconsider the resignation or, at least, to hold off. Leading doctors were consulted in New York and Chicago. Teamwork was established and science began its loving fight to halt the spread of the dread disease.

With his usual calm composure and objective viewpoint, Harry Boardman arranged to become the "human guinea pig" to this noble effort. His Company and fellow associates joined the battle as best they could with the burden falling heavily on his lifelong partner, Bess Boardman. She journeyed with him to New York so he could create history in his grueling task of presiding at all-day meetings of the Boiler Code Committee. She stayed with him weeks at a time in the hospital, tending to him by day and sleeping at night on a small hospital cot. Mercifully, this ordeal ended on August 6th.

Harry is gone. His accomplishments, both for his Company and the engineering profession, will live on for many, many years. A mere recital of these accomplishments would be lengthy, and, perhaps, serve no usual purpose in this message. A great teacher, a humanitarian and, above all, a personal friend has passed on. To some of us he was a "big brother," assisting with his wise counsel, helping us with our difficulties, pouring oil on troubled waters, indicating the advantages of moderation, praising us in our little successes, inspiring us to accomplish greater tasks and yes, if necessary, restraining us in attempted excesses.

I know that many others will join me in wishing that we may live up to the expectations held for us by Henry Clow Boardman.

W. Spraragen
Director
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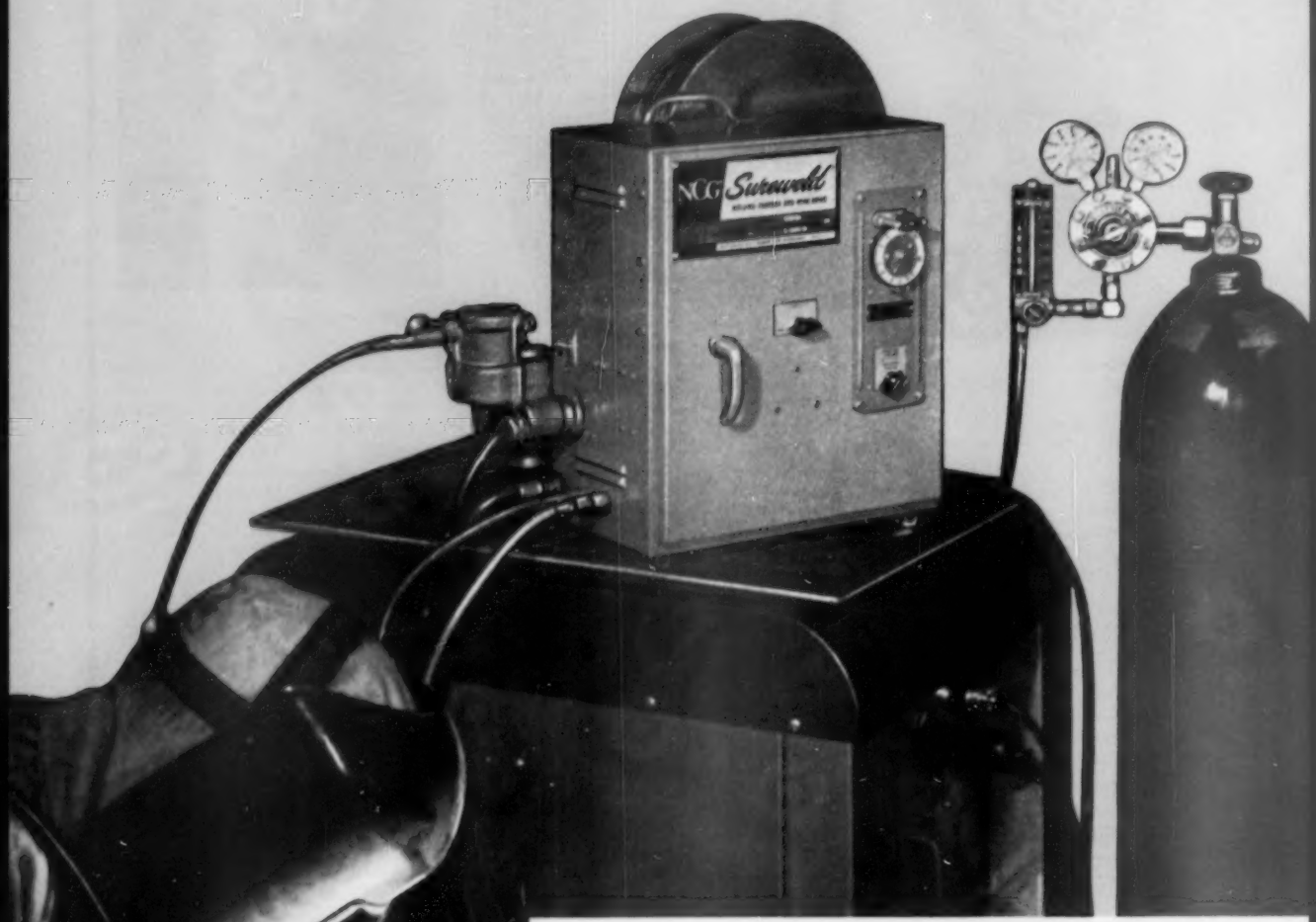

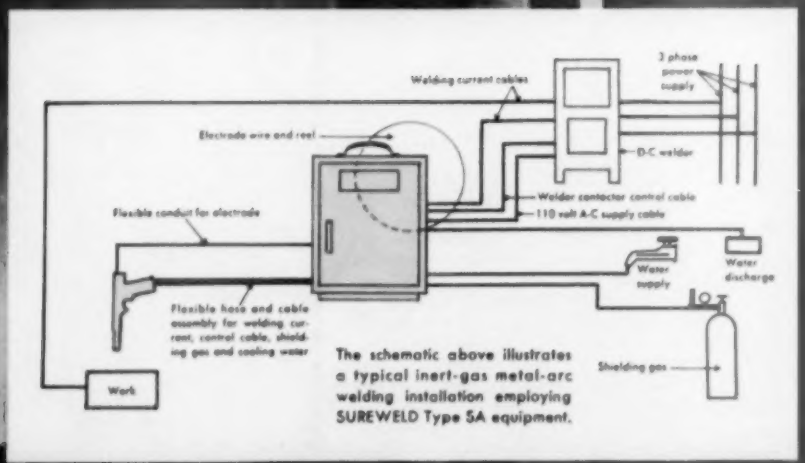
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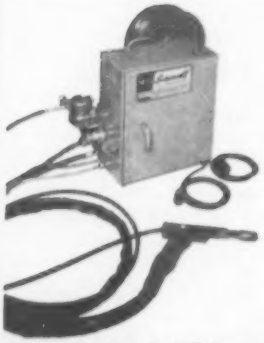

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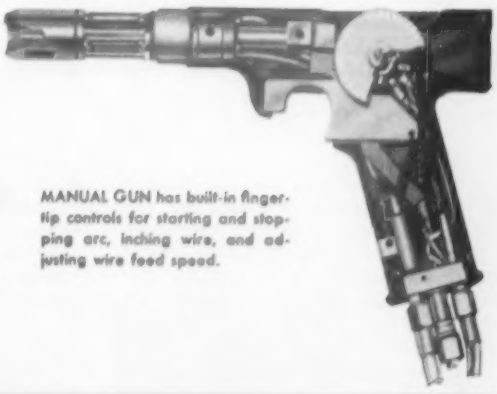

MANUAL GUN has built-in finger-tip controls for starting and stopping arc, inching wire, and adjusting wire feed speed.

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NEWS of The Industry

Bureau of the Census Reports on Electrical Welding Apparatus Industry

During 1954, value added by manufacture in the Electrical Welding Apparatus Industry amounted to $79 million, an increase of 37% over 1947, according to preliminary results obtained from the 1954 Census of Manufactures conducted by the Bureau of the Census, Department of Commerce, and published in Census Bulletin MC-36-1.4, *Electrical Welding Apparatus Industry*. Average employment in this industry has increased 12% since 1947 (when the last Census of Manufactures was taken) to a total of 8.2 thousand employees in 1954. The industry shipped products valued at $169 million in 1954, an increase of 63% over 1947. The industry's cost of materials, fuel, electricity and contract work increased 94% between the two years, from $46 million in 1947 to $90 million in 1954.

"Value added by manufacture," referred to above, is derived by subtracting the cost of materials, etc., from the value of shipments. It avoids, therefore, the duplication in the value of shipments which results from the use of products of some establishments as materials by others and is the best value measure available for comparing the relative economic importance of manufacturing among industries and geographic areas.

The electrical welding apparatus industry represents manufacturing establishments engaged primarily in the manufacture of electrical welding apparatus, electrode holders, and other welding apparatus. Establishments primarily engaged in manufacturing gas welding apparatus are classified in Industry 3542, Metalworking Machinery. The industry classification for the Electrical Welding Apparatus Industry used in the 1954 Census of Manufactures is based on the Standard Industrial Classification.

The value of shipments, as reported by establishments classified in the Electrical Welding Apparatus Industry, consisted not only of products described above as primary to the industry, but also included the value of secondary products (which are primary to other industries). The $169 million total value of shipments reported by establishments classified in Industry 3617, Electrical Welding Apparatus, consisted of $165 million manufactured products and $4 million miscellaneous receipts for contract work, repair work, sales of scrap, etc. The $165 million product shipments were accounted for by $149 million of electrical welding apparatus and other products primary to the industry, and $16 million of products primary to other industries (e.g. electric motors). Thus, the industry's shipments of Electrical Welding Apparatus represented 90% of its total manufactured product shipments (primary and secondary). This figure describes the "primary product specialization ratio," that is, the extent to which plants classified in an industry "specialize" in making products regarded as primary to the industry. The 1947 primary product specialization ratio for the industry was 93.

59th Annual Meeting Held by ASTM

With a record registered attendance of 2896, the American Society for Testing Materials concluded its 59th Annual Meeting at Atlantic City on June 22. The Apparatus Exhibit held in conjunction with the meeting was also one of the largest ever held by the SOCIETY with 44 different exhibitors. At the week-long meeting, the Society held 32 technical sessions and approximately 700 technical committee meetings. The vigorous work of the Society's technical committees for many months was concluded with the presentation of their reports at the meeting.

R. A. Schatzel, vice-president and director of engineering, Rome Cable Corp., was elected president of the SOCIETY for a one-year term.

Highlighting the technical program were the educational Marburg Lecture presented by Charles E. Reed on "The Industrial Chemistry, Properties, and Applications of Silicones"; the H. W. Gillett Memorial Lecture by D. K. Crampton, "Structural Chemistry and Metallurgy of Copper"; and a Symposium on Solder reported to include some of the most important discoveries on the subject for several years.

Sixteen papers were presented covering the science, metallurgy and physics of soldering. The four sessions included papers on such subjects as dip soldering printed circuits, soft solders, fluxes, "tin disease," aluminum soldering, quality control of manual soldering, and ultrasonic soldering.

Two papers suggested new approaches to specific standardization practices. L. Pessel of the Radio Corporation of America proposed a numerical evaluation system for soft solders, fluxes and solderability. This system showed significant correlation with practical performance, and may prove generally useful in advancing soldering technology. The second was a proposed method for testing and evaluating the joint properties of a copper liner soldered in an aluminum casting presented by M. V. Davis of Anderson Electric Corp. This method measures the strength of solder bond between the copper liner and aluminum casting used for making bimetallic electrical conductor connections. It provides an empirical quantitative measurement of the joint strength of the solder bond.

COMING EVENTS

A Calendar of Welding Activity

AWS National Meetings

1956 Fall Meeting:
October 8–12, Hotel Cleveland, Cleveland, Ohio

1957 Spring Meeting and Welding Show:
April 8–12, Hotel Sheraton, Philadelphia, Pa.

NWSA Zone Meetings

West Central Zone Meeting:
October 29–30, Hotel Nicolett, Minneapolis, Minn.

Western Zone Meeting:
November 1–2, St. Francis Hotel, San Francisco, Calif.

Southeastern Zone Meeting:
December 3–4, Dinkler-Tutwiler Hotel, Birmingham, Ala.

Southwestern Zone Meeting:
December 6–7, Statler-Hilton Hotel, Dallas, Tex.

National Metals Exposition

Thirty-eighth National Metal Exposition and Congress:
October 8–12, Cleveland Public Auditorium, Cleveland, Ohio

BETTER FASTER
Low Temperature EUTECTIC WELDING ALLOYS
STRONGER WELDS

EUTECTIC WELDING NEWS

Plant, Research Laboratories and World Headquarters

PUBLISHED BY EUTECTIC WELDING ALLOYS CORPORATION, 40-40 172 STREET, FLUSHING 58, NEW YORK, N. Y.
Warehouse-Service Centers in Atlanta, Chicago, Dallas, Berkeley, Montreal (Quebec), and other leading industrial areas.
In Canada: Eutectic Welding Alloys Company of Canada, Ltd.

NOW—KIRKSITE DIES CAN BE REPAIRED EASILY

Modern metallurgy has opened the door to a practical, low cost way to weld zinc die castings. This development by Eutectic Engineers permits repairing formerly discarded costly Kirksite dies.

Safe, sure, fast welding of zinc die castings is assured with EutecRod 196, the modern "Low Temperature Welding Alloy" specifically formulated for zinc alloys. This advanced alloy now saves industry thousands of dollars by reclaiming damaged and worn castings. EutecRod 196 is an easy-to-use bead forming alloy, perfect for build-up of worn or missing parts.

The low heat required eliminates the need to fuse and possibly damage the parent metal as with conventional welding materials. This means rapid joining of zinc die castings without puddling or melting the base metal, and preclusion of distortion or warpage caused by high heat. EutecRod 196 is used with Eutector Flux 196, applied first and heated. Liquefaction of the flux indicates the proper temperature for application.

Welded Kirksite mold ready for service

In addition to being a perfect color match for zinc die casts, EutecRod 196 is highly fluid. It can be used to join zinc die cast to other metals — brass, bronze, even aluminum. Large sections can be rebuilt by first melting the alloy on a cold plate and then joining the built-up alloy to the original part.

TOOL AND DIE SHOPS SAVE THOUSANDS WITH TINNING

Carburizing steel for tools and dies presents problems. It is often desirable to have parts of the metal remain soft for ease of subsequent drilling. Many tools require threading after carburizing. The usual process of welding pads on the piece before carburizing, and then machining off the pad, often leaves surplus metal when the pad is cut off.

Using Eutec-TinWeld, a paint-on, solder-type paste, also a perfect tinning compound, saves thousands of hours and dollars. Simply paint it over the area to be kept soft or protected. A torch melts the Eutec-TinWeld which later runs off during the heat treating. The area where it was applied remains soft. Base metal should be clean and oil-free before application.

"LOW HEAT INPUT" INCREASES PRODUCTION 500%

Excessive, costly rejects while fusion welding three copper pipes to a machined bronze casting led an Eastern manufacturer of heating equipment to check for savings with modern fabricating.

The brazing technique was tried. .388 ounce of filler alloy and nine minutes were saved on each assembly. A Eutectic District Engineer then suggested a cost analysis test with EutecRod 1801, a special capillary thin-flowing high silver alloy used with Eutector Flux 1801.

The three tubes were pre-fluxed and set up simultaneously; a large torch tip producing a broad flame was used. When the flux liquefied EutecRod 1801 was fed into the joint. The moving torch plus the superior capillarity of EutecRod 1801 prevented localized overheating and distortion as uniform fillets formed around the entire circumference of each tube.

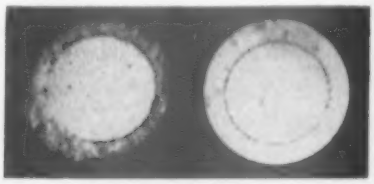
Even less skilled weldors produced perfect joints with thin flowing EutecRod 1801. Filler alloy required was cut from nearly two ounces of conventional alloy to 2/10 ounce of EutecRod 1801. Simultaneous joining of the three pipes increased production over 500%. The joints showed superior strength, corrosion resistance and "eye appeal." EutecRod 1801 reduced working temperatures at least 600 degrees F. Distortion and warpage were eliminated; the tubes perfectly parallel.

Overall view of the three fabrication methods. Left—fusion method showing heavy fillets, poor appearance and considerable distortion. Center—"brazing" results in better appearing, although still excessive fillets and some distortion. Right—EutecRod 1801 produces smooth, thin fillets and no distortion.

EUTECTRODE 2101 FOR ALUMINUM DRAWS APPLAUSE

A welding company writes us about "The remarkable performance of the new EutecTrode 2101 with extruded coating . . . in our early work, extensive tests were made using inert-gas arc, oxy-acetylene torch, and DC arc welding with commercially available aluminum electrodes, with hand dipped coatings. With EutecTrode 2101, we are able to get the desired quality of welds with 33% less preheat, 80% less rework to free slag in the difficult-to-reach areas, and with 25% less amperage. Superior wetting action with minimum spatter was apparent immediately."

Evidence of the superior performance of the new EutecTrode 2101 continues to come in. Air brake assemblies developing cracks from freezing were repaired using EutecTrode 2101, saving hundreds of castings costing $48.50 each. Spider ends of truck trailer wheels were repaired with fast melting, "Low Amp" EutecTrode 2101 without warpage or distortion. Housing for a Boston gear reduction unit was repaired in one hour with EutecTrode 2101 when mounting lug cracked. The repair was made with the lubrication left in the housing.



Conventional aluminum electrodes with hand dipped coatings (photomacrograph, left above) cannot provide the amazing arc stability, the absence of fingernailing and tailing, and the all-position weld-ability of the new EutecTrode 2101 with smooth extruded coating (right, above).

XYRON 2-25 SAVES $20,000 CONDENSER

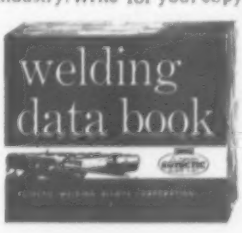
A West Coast manufacturer expected a costly salvage job on a smashed $20,000 cast iron condenser. About 150 lbs. of the new, advanced, porosity and crack-free, strontium-aluminum bearing "Low Amp" Xyron 2-25 for cast iron and alloy cast irons produced a highly successful repair. "Eutectic's" ChamferTrode was used to chamfer out the cracks. The entire job was done in 99 man-hours.

Increasing use of nodular, ductile cast irons has introduced a new group of problems never before experienced in repairing and fabricating gray cast iron. Crack-free, Xyron 2-25 makes it ideal for the newest alloys. Its advantages over conventional nickel electrodes—essentially non-cracking and low heat input—makes it ideal for repair of cracked motor blocks, machine bases, motor and gear housings, transmission cases, cams, levers and for building up missing sections, filling in holes and defects.

FREE!

POCKET SIZE 168 PAGE GUIDE TO STRONGER, FASTER WELDING

WELDING DATA BOOK . . . the most complete reference of its kind: A valuable aid for shop foreman, weldor, purchasing agent. Thousands of suggestions for time and money savings through welding for every industry. Write for your copy.



"EUTECTIC" WELDING HEADLINES • TIME-MONEY-MACHINERY SAVERS

"specialize" in making products regarded as primary to the industry. The 1947 primary product specialization ratio for the industry was 93.

Sales and Service Engineer Named by Wall Colmonoy

Appointment of Lawrence C. Connolly as sales and service engineer for Colmonoy products in the middle-Atlantic states has been announced by W. P. Clark, vice-president of Wall Colmonoy Corp. 19345 John R St., Detroit 3, Mich.

In his new position, Mr. Connolly will have his offices in Morrisville, Pa. He will be responsible for providing hard-facing application and development engineering assistance to industrial equipment manufacturers and users in the middle Atlantic area.

Mr. Connolly studied metallurgy at Temple University and business administration at Alexander Hamilton Institute.

York Engineering Moves

York Engineering Co., Chicago manufacturer of York 77 Flux, Spat-R-Pruf Compound and other related merchandise, has announced its removal into its new, modern large office and factory building at 2711 S. Kedzie Ave., in Chicago. York Engineering Co. was founded in 1931.

New G.E. Welding Distributor

DuPuy Oxygen & Supply Co., of Waco, Tex., has been named a General Electric welding equipment distributor.

The new distributor, located at 1429 Webster St., will handle the complete line of General Electric welding equipment. This includes a-c, d-c, inert-arc, semiautomatic and automatic, and atomic-hydrogen equipment, in addition to electrodes and accessories.

Stoody Appoints Distributor

A change in Chicago distributors has been announced by Stoody Co., Whittier, Calif. Hardfacing Sales & Engineering Co., has been appointed exclusive distributor for the territory which includes roughly the northern third of Illinois, the southeastern section of Wisconsin and the northwestern portion of Indiana. This territory includes the trade areas of Chicago, Milwaukee, Dubuque, Davenport, Iowa and Gary, Ind.

The company's offices are located at 242 E. 103rd St., Chicago 28.

Expansion Program for Tube Turns

Tube Turns, Louisville, Ky., has bought 13 acres of industrial property for expansion purposes.

The property, formerly owned by the Louisville Transit Co., is adjacent to Tube Turns' main plant at Twenty-eighth and Broadway. Tube Turns is a division of National Cylinder Gas Co., Chicago.

Earlier, 2.6 contiguous acres were acquired and the new production area now totals 15.6 acres.

The two real estate transactions will be followed by a substantial investment in additional equipment.

INTERNATIONAL WELDING NEWS

I.I.W. Commission V— Testing, Measurement and Control of Welds

by Alexander Gobus

This group has as its scope all factors involved in nondestructive testing.

Their effort includes research into applicable methods, development of procedures and creation of reference material, such as radiographs. These radiographs can be used as standards by groups having product responsibility.

Radiography in Europe uses both X-ray and gamma-ray sources. In general, gamma-ray sources do not find widespread application. The British, for example, have proposed the prohibition of the use of cobalt 60 for steel welds less than $1^1/_2$ in. thick.

X-ray equipment generally varies from the American in that the trend in Europe is to adhere to lower kv equipment. Penetration of the heavier sections is accomplished by the use of fluorescent intensifying screens. In this country the preference is to use higher kv equipment. The use of lead intensifying screens, therefore, remains practicable. Of course, the objectionable graininess accompanying calcium tungstate screens is eliminated by the use of lead.

One of the most interesting advances in the search for filmless radiography has been the adaptation of electronic fluoroscopy to production inspection of gas pipe welds at the rate of 10 fpm. This development originated in Germany where several plants have been using this method for almost two years. Since the method has been accepted by the responsible authorities in charge of product acceptability it is believed that the method will come to the attention of Commission V.

The I.I.W. has made great strides in the study of "penetrometers." First, it was recognized that the word itself indicated a gage by which defects could be measured. This is not so. The word has been abandoned in favor of "Image Quality Indicator." This then describes its true function. A device for checking on radiographic technique factors, such as FFD (film-focus distance), type of film, KVP, etc.

The latest proposal of a subcommission states that the USA type of I.Q.I. is more difficult to pick up than the European D.I.N. (wire) type by about 50%. It is expected that I.I.W. will eventually go to some form of I.Q.I. with holes.

Magnetic particle testing is constantly in use. It is expected that a set of reference photographs will be developed similar to the material ready for publication by ASTM.

The analogous dye penetrant method, while in use, has not received much attention in the way of reports.

Ultrasonics testing has received considerable attention by equipment manufacturers. Application work by welding engineers and metallurgists has been intense. Much of the work involved has been by correlation with radiography.

Much of the early work reported indicated that ultrasonic testing of welds was not reliable enough to determine acceptability of the product. More recent information indicates that some advances have been made. The improved test results were obtained where weld design for ultrasonic testing was permissible. In other words where the weld design was favorable for testing without impairing the serviceability of the weldment.

It is hoped that further reports will explain in detail what the factors are that may make this method another of the tools available for the control and inspection of welds.

The indefatigable work of Lambertus van Quwerkerk in his role as Chairman of this Commission is highly commended.

The work is quite evenly shared by most of the membership countries, with Holland, Finland, Sweden and Italy contributing ever so much of value.

Alexander Gobus is the official American delegate on Commission V of the International Institute of Welding.

New G.E. Sales Offices for Tubes

The General Electric Co. has established two new district sales offices for tubes and other electronic components.

John E. McElfresh has been appointed district sales manager of the Lansing, Mich., district which covers the major part of Michigan and a section of Ohio, including the metropolitan trading areas of Lansing, Flint, Grand Rapids, Kalamazoo, Saginaw and Toledo.

Floyd S. Anderson has been appointed district sales manager of the Philadelphia district which covers southeastern Pennsylvania, southern New Jersey, eastern Maryland and all of Delaware, including the metropolitan trading areas of Philadelphia, Atlantic City, Wilmington, Trenton and Salisbury.

New United Kingdom Distributor for Lincoln

The Lincoln Electric Co. of Cleveland, Ohio, according to an announcement by James F. Lincoln, chairman of the Board, has terminated its association with Lincoln Electric Co., Ltd., of Welwyn Garden City, England. The sole distributor in the United Kingdom for all of their products is now Armco Ltd. of 75 Grosvenor St., London, W.1.

Airco to Build Plant in Los Angeles Area

Air Reduction Pacific Co. will build a new air liquefaction plant in the Los Angeles area, it has been announced today by John A. Hill, president of Air Reduction Co., Inc. The new plant is designed to produce daily 55 tons of high purity liquid oxygen, 15 tons of liquid nitrogen, and 3½ tons of liquid argon. The cost of the plant, including related delivery facilities, will be in excess of $7,500,000.

The plant is scheduled for completion during the second half of 1957. It will supply the rapidly increasing demand for oxygen, nitrogen and argon in the California, New Mexico and Arizona industrial areas.

Depke to Hold Welderama

A Welderama and equipment exhibit, open to the public, will be held by Depke Welding Supplies, Inc., at their store at 628 E. Williams St., Danville, Ill., Wednesday, September 12th, and Thursday, September 13th, from 3 to 10 P.M.

There will be live demonstrations of inert-gas tungsten-arc welding, inert-gas metal-arc spot welding, machine cutting, hard surfacing, plow welding, and many other oxyacetylene and arc-welding processes.

Representatives of all of the exhibiting companies, whom Depke Welding Supplies, Inc., represents in the Danville, Champaign and Kankakee areas will be present to show their equipment and answer questions about welding and cutting. Refreshments will be served during both days and there will be door prizes for registered guests. Continuous color motion pictures on various phases of welding and cutting will be shown. As an added feature, there will also be an interesting new color cartoon on the use of oxygen medical purposes.

Weldaloy Adds to Sales Department

Recently announced by J. A. O'Grady, president of Weldaloy Products Co., Van Dyke, Mich., was the addition of John L. Drogas to the copper alloy sales department.

Before joining Weldaloy, Mr. Drogas was responsible for quotations and order contracts with W. W. Alloys of Detroit. Previous to that association he functioned as a sales engineer with Detroit Brass and Malleable Co. Before his stay with Detroit Brass and Malleable, Drogas spent seven years as an estimator, engineer and sales correspondent with Woodall Industries, Detroit plant.

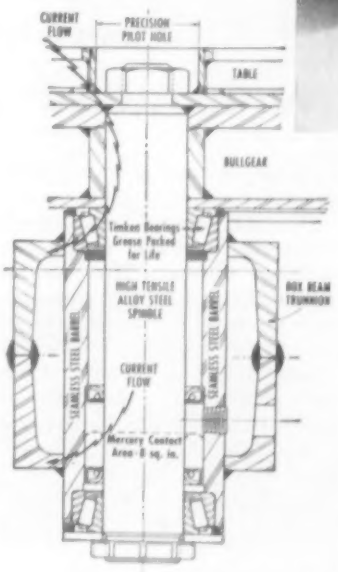
Resistance Welding Equipment Sales Continue to Rise

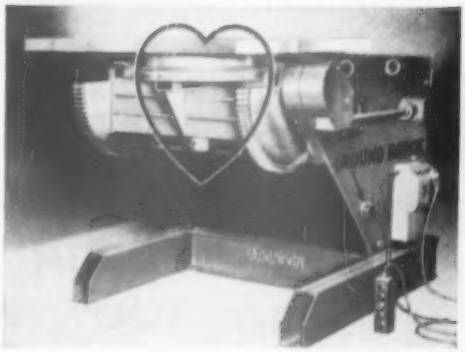
Monthly statistics released by the Resistance Welder Manufacturers' Association show that new business for the month of May has continued to show splendid gains.

The HEART of an ARONSON Positioner with BUILT-IN MERCURY GROUNDING

With ARONSON you get this
PLUS FEATURE
at NO Extra Charge:

2000 Amps. minimum Return Current SURE Conduction.





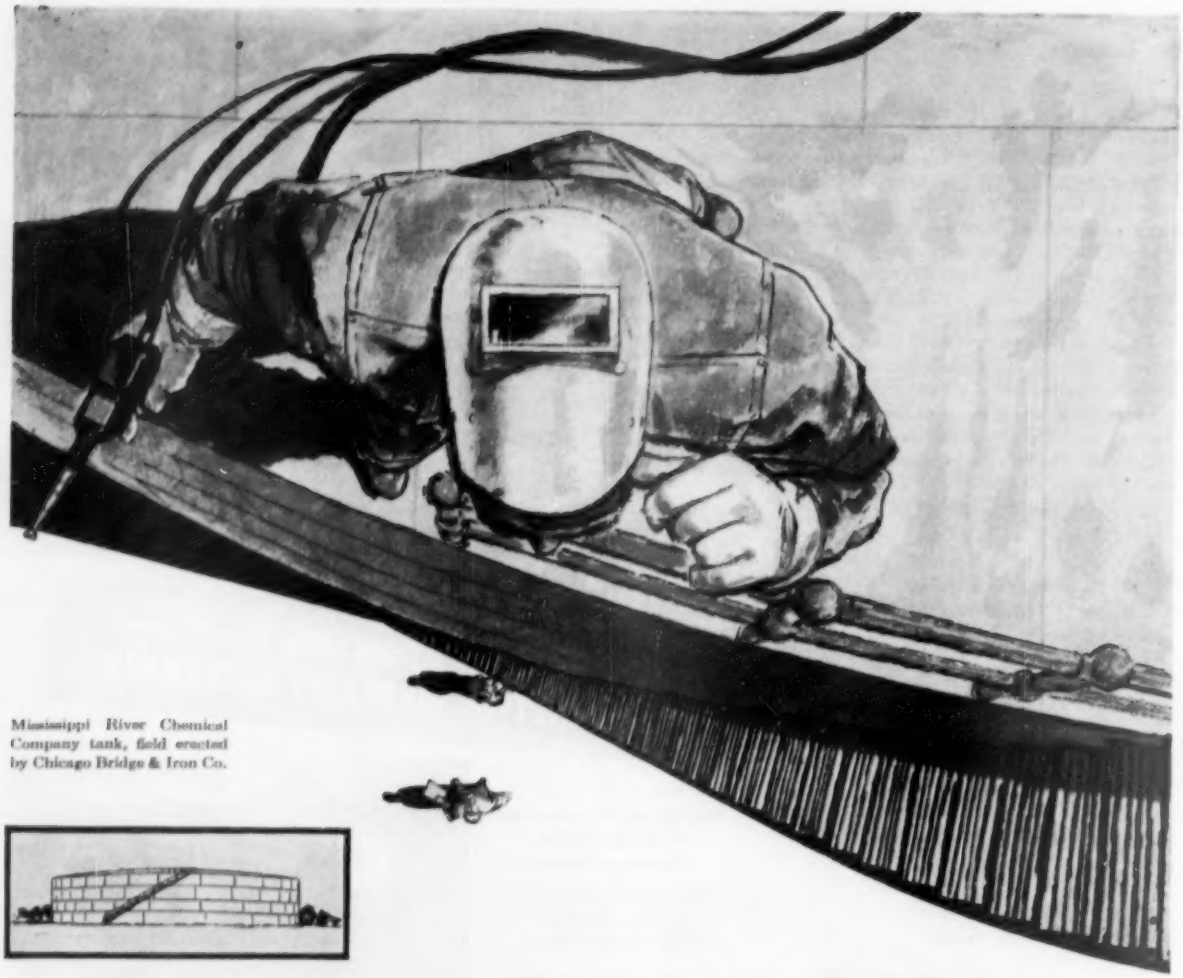
- Not a gadget *extra attachment.*
- Nothing to wear out. Nothing to service.

If your welds are erratic, chance are your ground circuit is at fault.

ARONSON has over 200 STANDARD Models in TEN different types of Welding Positioners to choose from. You can be *sure* ARONSON POSITIONING supplies what you need to make the best welds at the lowest cost.

Call your nearby ARONSON DEALER, or write the factory.

another Quality POSITIONER by **Aronson MACHINE COMPANY**
ARCADE, NEW YORK



Mississippi River Chemical Company tank, field erected by Chicago Bridge & Iron Co.

World's Biggest All-Aluminum Tank Welded 100% With Alcoa® Alloys

This huge tank holds 2½ million gallons of highly corrosive ammonium nitrate. It's the world's largest aluminum tank—26 feet high and 128 feet across.

To handle the corrosive nitrate, the builder chose aluminum. For the highly stressed parts, Alcoa recommended Alloy 5052 which has a good combination of strength, corrosion resistance and weldability. We also recommended 5052 for the filler metal, a standard welding alloy, desirable here because of its corrosion resistance.

The big job was field erected, using the inert-gas, metal arc-welding process. The bottom course plates are 1¼ inches and upper courses are progressively thinner, with a ⅜-inch-thick top course. Welds on the finished job were subjected to a standard dye check test. The tank passed this and subsequent water pressure tests with flying colors.

Alcoa made all the aluminum used on this impressive project but we're more proud of the service we were able to render—advising on the alloys, helping get the job started, being Johnny-on-the-spot when any problems came up. We would like to help you weld . . . braze . . . solder in aluminum. Call your Alcoa distributor listed at right. ALUMINUM COMPANY OF AMERICA, 1741-J Alcoa Building, Pittsburgh, Pa.

Your Guide to the Best in Aluminum Value

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

For Immediate Delivery, call one of the Alcoa distributors listed below. He carries a complete range of alloys and sizes of Alcoa Etched Finished Welding and Brazing Rod, I. G. Consumable Electrode, Brazing Metal, Solder and Flux.

For technical assistance, contact the nearest Alcoa sales office, listed under "Aluminum" in the yellow pages of your phone book.

ALABAMA
Birmingham
Hinkle Supply Co.

CALIFORNIA
Los Angeles
Pacific Metals Company, Ltd.
San Francisco
Pacific Metals Company, Ltd.

COLORADO
Denver
Metal Goods Corp.

CONNECTICUT
Milford
Edgcomb Steel of New England, Inc.

FLORIDA
Jacksonville
Florida Metals, Inc.
Miami
Florida Metals, Inc.
Tampa
Florida Metals, Inc.

GEORGIA
Atlanta
J. M. Tull Metal & Supply Co., Inc.
Southern Oxygen Co.

IDAHO
Boise
Pacific Metal Co.

ILLINOIS
Chicago
Machinery & Welder Corp.
Moline
Machinery & Welder Corp.

KENTUCKY
Louisville
Williams & Co., Inc.

LOUISIANA
New Orleans
Metal Goods Corp.

MARYLAND
Baltimore
Southern Oxygen Co.
Whitehead Metal Products Co., Inc.

MASSACHUSETTS
Cambridge
Whitehead Metal Products Co., Inc.

MISSOURI
Kansas City
Metal Goods Corp.
St. Louis
Metal Goods Corp.

NEW HAMPSHIRE
Nashua
Edgcomb Steel of New England, Inc.

NEW JERSEY
Camden
Southern Oxygen Co.
Harrison
Whitehead Metal Products Co., Inc.

NEW YORK
Albany
Eastern Metals Warehouse, Inc.
Buffalo
Whitehead Metal Products Co., Inc.
New York
Whitehead Metal Products Co., Inc.
Syracuse
Brace-Mueller-Huntley, Inc.
Whitehead Metal Products Co., Inc.

NORTH CAROLINA
Charlotte
Southern Oxygen Co.
Greensboro
Southern Oxygen Co.

OHIO
Cincinnati
Williams & Co., Inc.
Cleveland
Williams & Co., Inc.
Columbus
Williams & Co., Inc.
Toledo
Williams & Co., Inc.

OKLAHOMA
Tulsa
Metal Goods Corp.

OREGON
Portland
Pacific Metal Co.

PENNSYLVANIA
Philadelphia
Southern Oxygen Co.
Whitehead Metal Products Co., Inc.
Pittsburgh
Williams & Co., Inc.
York
Southern Oxygen Co.

TENNESSEE
Kingsport
Southern Oxygen Co.

TEXAS
Dallas
Metal Goods Corp.
Houston
Metal Goods Corp.

UTAH
Salt Lake City
Pacific Metals Company, Ltd.

VIRGINIA
Norfolk
Southern Oxygen Co.
Richmond
Southern Oxygen Co.

WASHINGTON
Seattle
Pacific Metal Co.

WASHINGTON, D. C.
Southern Oxygen Co.

WISCONSIN
Milwaukee
Machinery & Welder Corp.

New orders reported by RWMA Members for May totaled more than $83\frac{1}{2}$ million and brought the five-month period to 103% above the first five months of 1955.

Shipments for May were also at a high level, and for the five-month period are 48% ahead of the same period last year.

Valley Welding Supply Moves to Larger Quarters

On June 1, 1956, Valley Welding Supply, Inc., moved to new and larger quarters located at 1828 W. Wisconsin Ave., Appleton, Wis. On June 15th and 16th they held a Welderama and Open House.

Eight suppliers cooperated with Valley Welding by exhibiting and demonstrating to their customers and prospects. The exhibitors were Alloy Rods Co., National Cylinder Gas Co., Miller Electric Manufacturing Co., A. O. Smith Corp., American Manganese Steel Division, Bay State Abrasive Products Co., Heath Engineering Co., and Aronson Machine Co.

A total of 375 people registered at the Open House.

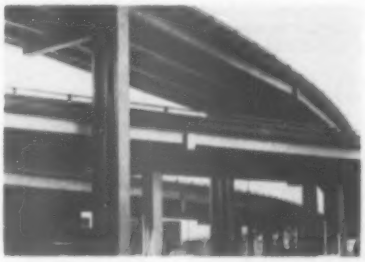
Progress in Welded Highway Bridges

A recent survey of state bridge departments, made by The James F. Lincoln Arc Welding Foundation of Cleveland, Ohio, has revealed an increasing trend toward the use of welded bridges in the country's rapidly expanding highway system. Of the 39 state bridge departments responding to the survey, 15, or 38%, were using an increasing number of welded highway bridges. Another 13 states, or a total of 72%, were using welding for certain details such as cover plates, diaphragms, shoes, etc. Many of these states were considering adopting completely welded designs for more of their bridges.

Reported savings in steel in typical welded bridges, ranged up to 20%.

Crossing of U. S. Highways 84 and 81 in McLennan County, Texas. Top structure provides four traffic lanes and lower, six traffic lanes. Upper bridge is 1566 ft long and lower bridge is 550 ft long

Service road over Hoover Dam Reservoir Project City of Columbus, Ohio, eight 85-ft 3-in. spans of 100% welded haunched plate girders with a 24-ft wide roadway and two 1-ft 6-in. safety curbs



The 9th and 10th St. connections of the all-welded San Francisco Freeway Viaduct. This is the world's largest all-welded structure in terms of tonnage. Spans range up to 170 ft

Marais des Cygnes River Bridge at Trading Post, Kan.; 128-160-128-ft continuous, all-welded plate girder-bridge; four lines of girders with light X bracing. Girders are spliced with field welding

Australian Welding Institute to Hold 4th Annual Convention

The 4th Annual Convention of the Australian Welding Institute will be held in Brisbane, Queensland, from Monday, Oct. 8, to Friday, Oct. 12, 1956.

The program will include the presentation of the following technical papers:

Tuesday—October 9th

9:15 A.M.

"Application of Thermit in Welding," by R. Vogt, Sales Manager, Humes Ltd., Thermit Div.

"Equipment in the Sugar Industry and the Use of Welding Techniques," by A. J. McCracken, General Manager, Bundaberg Foundry Co. Ltd.

8:00 P.M.

"New Metals and New Techniques in Industry," Guest Lecturer: Professor H. W. Worner, D.Sc., Fellow Institution Metallurgists (London), Professor of Metallurgy, University of Melbourne.

Thursday—October 11th

9:15 A.M.

"Some Problems in Welded Railway Rolling Stocks," by B. Fitton, Design Engineer, Commonwealth Engineering (Qld.) Pty. Ltd. Followed by inspection of Commonwealth Engineering (Qld.) Pty. Ltd., Rocklea.

2:00 P.M.

"Arrest of Brittle Cracks in Ship Plates," by J. Hunter, Principal Welding Engineer, Department of the Navy. Followed by visit to Evans Deakin Shipyard, Kangaroo Point.

8:00 P.M.

Annual General Meeting—followed by paper entitled "Automatic Hard-Surfacing with the Electric Arc," by H. James, Chief Technical Officer (Sales), E.M.F. Electric Co. Pty. Ltd., and S. Wells, Sales Engineer, E.M.F. Electric Co. Pty. Ltd.

Friday—October 12th

9:15 A.M.

"Fatigue Testing of Spot and Butt Welds," University of Queensland.

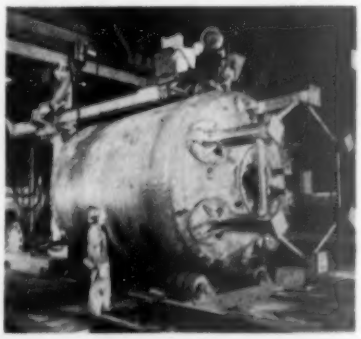
"Rolled Steel Fabrication as Applied to Machine Tools," by John O. Ogden, Managing Director, Welded Products Pty. Ltd.

In addition, there will be several visits of inspection on Tuesday afternoon, all day Wednesday and Friday afternoon.

W. S. Coates, Federal President of the Australian Welding Institute and a member of the AMERICAN WELDING SOCIETY, has issued a general invitation to all members of AWS to attend this convention in Brisbane.

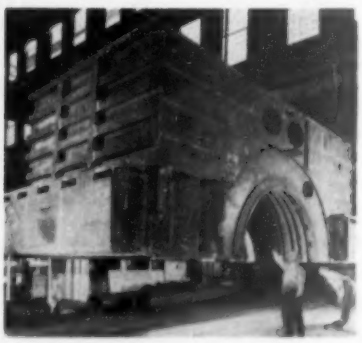
•

AUTOMATIC WELDER AT WORK



Giant automatic welder at work on a viscose blender of 8000-gal working capacity in the Pittsburgh plant of Dravo Corp. The machine operator's station is located on the boom which carries the welding electrode. This permits constant inspection of welding action as the piece is rotated beneath the tip on power-driven rolls. High quality uniform welds are produced without the time lost in shifting such heavy work pieces for normal down-hand welding

WHOPPER OF A WELDMENT



This 98-ton base section for the low-pressure element of the world's first 300,000-kw steam turbine-generator unit is the heaviest weldment produced to date for a steam turbine by Allis-Chalmers Manufacturing Co. It measures 12 ft high, 15 ft wide and 30 ft long. The entire steam turbine-generator unit being built for the River Rouge plant of The Detroit Edison Co. will weigh 1615 tons.

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CABLE CONNECTORS

Now, for the first time, a 110-volt portable molding kit that anyone can operate, to seal cable connectors in waterproof, shockproof, neoprene insulated sleeves . . . in the plant . . . in the field . . . in minutes!

Tapered sleeve connection assures a waterproof joint when connector is locked. Low cost . . . rugged . . . simple . . . economical . . . factory and field test proven.

New kit, with its heavy-duty crimping and vulcanizing press plus 4 parts, are all you need. Eliminates soldering, short circuits, flexing and breaking of cable strands, down-time, wear, breakage and corrosion. Connectors employ a positive lock for high conductivity yet can be taken apart instantly.

Get the facts today on this revolutionary new product. Write for Catalog No. 131, or see it and the complete CAM-LOK line at The METAL SHOW, Booth No. 2520, Oct. 8–12, Cleveland.

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Imagine a holder weighing half as much as your helmet!

capacity
300 AMPS
ELECTRODES
1/4 - 1/16

TRY

MODEL AL-300

TWECOTONG

it weighs just 13½ ounces

Here is a holder that's made for the man who wants a lightweight holder for easier welding. Its lower body and upper lever are forged aluminum alloy . . . with current carrying capacity equal to the much heavier copper alloys. Like all TWECO electrode holders, TWECOTONG AL-300 has tips and body insulation of SUPER-MEL laminated glass cloth . . . the toughest, safest and longest lasting holder insulation made.

The upper and lower jaws of AL-300 TWECOTONG are quickly and easily replaceable, as are all other parts. The jaws hold the electrode with a vice-like grip so you know where it is at all times; yet they open easily to change rods. You can install this holder on the line in one minute flat. Just bare the cable end, insert it in the reamed hole in the holder body and tighten one cone shaped screw . . . that's all!

SEE YOUR LOCAL WELDING SUPPLY DISTRIBUTOR

Write for FREE Catalog picturing complete line of Arc Welding Accessories and TWECO-LITE Aluminum Arc Welding Cable.

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MANUFACTURERS OF ELECTRODE HOLDERS • GROUND CLAMPS • CABLE CONNECTIONS FOR ELECTRIC WELDING

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DYNAMITE ACTION!

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Assures penetration, with pressure, to the most hard to get at objects. Shoots a stream three feet if needed.

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Always ready at the touch of a button. The fastest acting non acid, non alkali penetrating oil known or money back.

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Spray container eliminates wasted surplus and time in application. Cannot leak or spill.

4. HANDY
Carried easily and is always ready for use. No chance for ingredients to weaken by exposure to air from a misplaced cap.

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Marla Spray Penetrating Oil is used to free the most corroded bolts, screws, pipe threads, bearings, bushings, pulleys, manifolds, valve guides, locks or any other stuck together metal parts.

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Union Carbide Opens New Research Laboratory

The new Parma, Ohio, research laboratories of National Carbon Co., a Division of Union Carbide and Carbon Corp., will be dedicated September 18th. Designed primarily for basic research in chemical and solid state physics, the multimillion-dollar laboratory brings to seven the number of major research centers operated by divisions of Union Carbide and Carbon Corp., which in 1955 spent approximately $43 million on research.

The new laboratory facilities are already in operation. A tour of the laboratory will be included in the dedication ceremonies to be attended by company officials and invited guests from industry and the fields of science and education.

The new laboratory contains approximately 175,000 sq ft of floor space, and is located near the center of a 126-acre plot on Snow Road in suburban Cleveland. Designed for extrence flexibility, with provisions for expansion, the main laboratory building consists of 158 laboratory modules, or individual research units, fully equipped with all the usual service lines and, in addition, unusual features such as lines distributing various rare gases.

Heading up the new laboratory is Dr. Robert G. Breckenridge, 40-year-old National Carbon physicist, who previously had a broad background of research experience and accomplishment as Chief, Solid State Physics Section, U. S. National Bureau of Standards, and Head of Physics Branch, Office of Naval Research at Washington, D. C

Display Your
AWS Certificate!
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IWDA Elects

The annual meeting of the Independent Welding Distributors Assn. was recently held at San Diego, Calif.

O. H. Koll, owner of Welders Supply Service, Modesto, Calif., was elected president for the forthcoming year. W. V. Raymond, president and general manager of California Welding Supply Co., Stockton, Calif. was elected vice-president. M. J. Andrews was re-elected secretary-treasurer.

The IWDA is an association of 25 independent welding supply distributors in the Western United States, Alaska and Hawaii. The organization was formed in 1947 in order that independent welding supply distributors might exchange information regarding business methods and trade practices.

INDEPENDENT WELDING DISTRIBUTORS MEET IN SAN DIEGO

Members of the Independent Welding Distributors Association shown at their recent annual meeting in San Diego, California

STAINLESS STEEL WELDING WIRE...

Spooled... layer wound to assure a smooth, even feed. Sizes: .035", .045", 1/16", 5/64" and 3/32" diameters.

Coiled... layer wound on rims for submerged arc welding. Sizes: 1/16", 5/64", 3/32", 1/8", 5/32", 3/16" and 1/4" diameters.

Cut Lengths... straightened and cut wire furnished in 36" lengths for inert arc and gas welding.

Sizes: .035", .045", 1/16", 5/64", 3/32", 1/8", 5/32", 3/16" and 1/4" diameters.

Two factors give

Drawalloy

CORPORATION

WELDING WIRE

best on-the-job performance

WEAR-O-MATIC HARD-FACING WIRE...

Coiled... precision drawn for perfect roundness to insure continuous, smooth feed with any automatic head. Available in six Types for hard-facing applications.

Drawalloy welding wire is a product of two factors—years of experience in the welding industry combined with the best wire mill drawing practices. The result is clean welding wire with the proper finish, temper, diameter tolerance and chemical analysis. It's a wire that produces the highest quality welds continuously—with an easy, sure feed and a constant, smooth arc.

See your distributor or write Drawalloy Corporation, Lincoln Highway at Alloy Street, York 13, Pennsylvania

Drawalloy

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The Wire Mill For The Welding Industry

YORK, PENNSYLVANIA

METAL & THERMIT DEDICATES NEW $2,500,000 CENTER

At an open house and luncheon on June 20, attended by approximately 700 people, Metal & Thermit Corp. dedicated its new general office building, recently completed as part of a $2,500,000 combined general office, research and distribution center, in the Woodbridge-Rahway area of New Jersey.

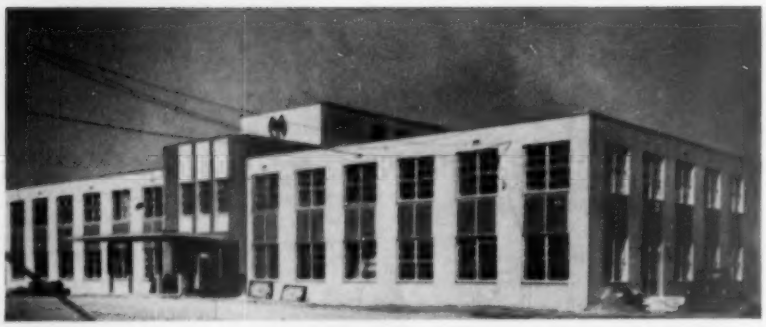
The affair was planned as an open house to welcome the employees, and their families, recently moved by Metal & Thermit from New York to New Jersey.

The ceremony was held in a large tent erected on the grounds adjacent to the new office building, and featured talks by H. E. Martin, Metal & Thermit president, William H. McLean, president, Chemical Division, Merck & Co., Inc., and Robert B. Meyner, Governor of New Jersey.

Following the talks, a box luncheon was served, after which the guests were conducted in groups on guided tours of the new offices.

The office building, a two-story 80-x 180-ft structure, houses approximately 250 general office employees, about half of whom were moved from the company's former offices in New York City. It is of yellow brick construction, matching the Metal & Thermit research laboratory erected in 1942. Air conditioned throughout, it is equipped with its own cafeteria.

The new center brings together at one point the company's general offices, a storage and distribution warehouse, sales offices, a central steam plant and enlarged research facilities. The existing research laboratory is being expanded to provide additional facilities including pilot plants and semiworks for organic and inorganic chemicals.



Metal & Thermit's new general office building in the Woodbridge-Rahway area of New Jersey

H. E. Martin, president of Metal & Thermit Corp., addresses approximately 700 employees, their families and invited guests

Guided tours of the new office building followed ceremony and luncheon. Left to right here are Donald C. Luce, president, Public Service Electric & Gas Co.; William H. McLean, president, Chemical Division, Merck & Co., Inc.; H. E. Martin, president, Metal & Thermit Corp.; Robert B. Meyner, Governor of New Jersey; Dr. C. K. Banks, Director of M & T Research

JOIN AWS!

Through membership in AWS you keep abreast of the latest developments in welding, welding engineering, welding metallurgy and procedures, by the contacts you make and through its local and national meetings and publications. Investment in AWS membership cost less than your daily newspaper, but brings you tremendous and perpetual dividends, and information on how to produce improved products, increase productivity, and lower production costs through modern welding procedures. Send for descriptive brochure to AMERICAN WELDING SOCIETY, 33 West 39th Street, New York 18, New York.

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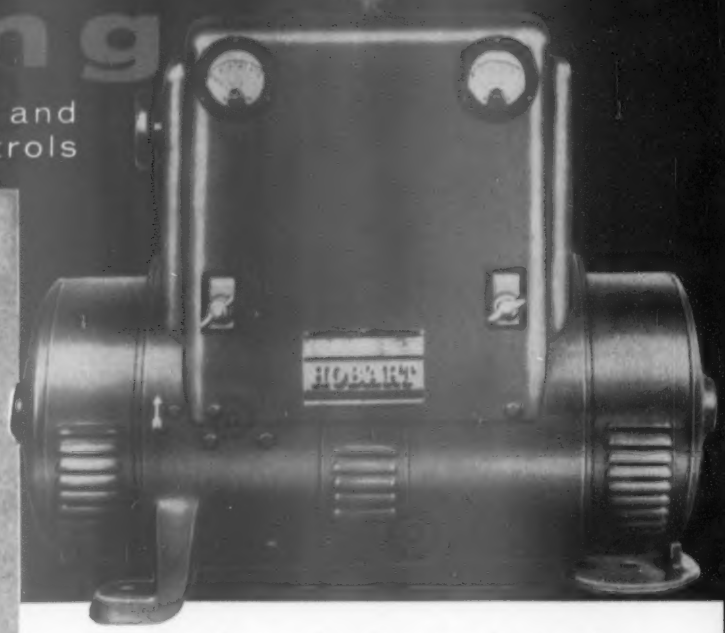
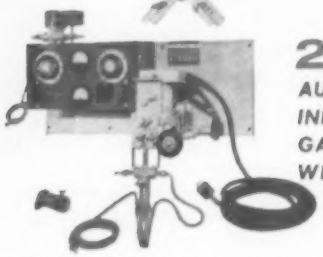
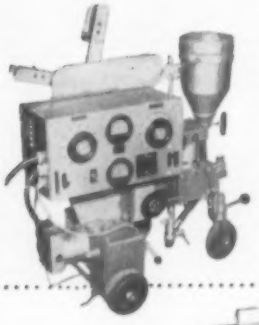


AUTOMATIC HEADS *available for:*

1. *FULLY AUTOMATIC SUBMERGED ARC AVAILABLE WITH OR WITHOUT BEAM CARRIAGE*



2. *FULLY AUTOMATIC INERT GAS WELDING*



3. *TRACTOR TYPE AUTOMATIC ARC WELDER*

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Many new advantages are now available in Hobart's "POWROMATIC" Constant Voltage power with simplified controls. Eliminates complicated electronic controls. You'll be amazed how easy you can use this new automatic and semi-automatic welding to speed your work and cut costs. Even less experienced weldors can double output and produce uniform high quality welds. You cannot afford to overlook automatic welding now that it's truly simplified and so easy to install and use. No obligation, write for complete information — **HOBART BROTHERS COMPANY, Box WJ-96, Troy, O. Phone 21223.**

See this equipment demonstrated at the **METAL SHOW** *Oct. 8 thru 12 Space 2541 lower exhibition hall*

HOBART TROY OHIO **WELDERS**

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_____ type automatic welding.

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NEW PRODUCTS

Iron-Powder Low-Hydrogen Electrode

The Air Reduction Sales Co. has just announced a new electrode, designated as Airco Easyarc 328, for all position welding of mild and low-alloy steels. It is of the low-hydrogen type with iron powder added to the coating for high welding speeds.

Airco Easyarc 328 is recommended by the manufacturer for welding hardenable steels; cold-rolled steels; low-alloy or mild steel when stress relieving is required; and weldments to be vitreous enameled after welding.

For more information about the new Airco Easyarc 328, contact Air Reduction Sales Co., a division of Air Reduction Co., Inc., 150 E. 42nd St., New York 17, N. Y.

Welding Flux

A new dry-type welding flux for use when applying Colmonoy nickel and cobalt base hard-surfacing alloys to hard-to-weld metals is now available from Wall Colmonoy Corp., 19345 John R St., Detroit 3, Mich.

Called Colmonoy Flux 6-20, the new material imparts excellent flow characteristics to hard-facing alloys, according to the manufacturer. Designed to include a unique eye-saving formula, it is said to contain no glare-producing salts. The new flux was developed for use in hard-facing iron and nickel base alloys containing chromium, titanium and/or aluminum. It is also excellent for use on cast iron parts.

Welding Fasteners

Availability of welding fasteners in a wide variety of sizes and types to meet customer's specifications has been announced by Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, N. Y. The fasteners include welding screws, spade and bent spade screws, collar studs and nuts and designs to meet special applications.

Additional information can be obtained by writing to Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, N. Y.

Rectifier Power Source

A new 1540-amp rectifier power supply, rated for 100% duty cycle for the submerged-arc process, has been announced by the General Electric Co.'s Welding Department.

Designed for operation on a three-phase 460 or 575 volt input (not reconnectable), the unit has an actual output range of 600 to 1600 amp, and can be operated continuously. It has a drooping volt-ampere characteristic, which limits the short circuit current.

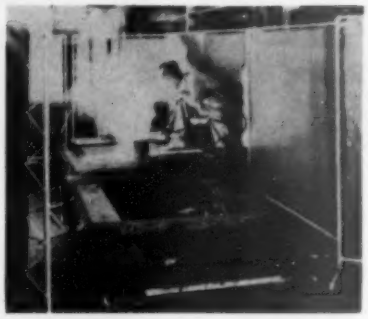
The input voltage is stepped down by a bank of three transformers of the moving coil design, and then rectified by a bank of selenium rectifiers. The coils are motor driven to provide remote current adjustment. Controls for contractor and current output are mounted on the unit's enclosure, and both can be operated from a remote control station.

For complete details, write to General Electric Co., Schenectady 5, N. Y.

Lightweight Welding Curtains

A nylon-plastic welding curtain has been developed by Herculite Protective Fabrics, Inc. Herculite is a combination of special vinyl and tough nylon resulting in a fabric which according to manufacturer, is almost indestructible.

Herculite welding curtains reportedly

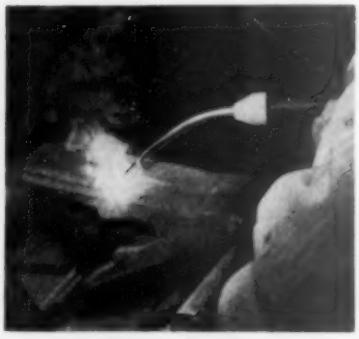


do not absorb shop oils and greases, are absolutely flame-proof, and colors offer continuous caution zone partitions in an area, and welding splash is completely localized.

For complete information, write to: Herculite Protective Fabrics, Department W, 140 Little St., Belleville 9, N. J.

"Tube Rods" for Hard Surfacing

The American Manganese Steel Division of the American Brake Shoe Co. announces a new line of "tube rod" electrodes specially developed for semiautomatic hard-surfacing.



Although the tube rods have been designed specifically for use with the AMSCO MF semiautomatic welder, they may easily be adapted for use with most semiautomatic machines, according to the manufacturer.

The new electrodes are $^{3}/_{32}$-in. diam. drawn tubular wire and act much like mild steel solid wire in the welding machine. The tube rod is a perfectly round steel-wire shell with the various alloys firmly enclosed within the work-hardened shell.

The special tubular construction of

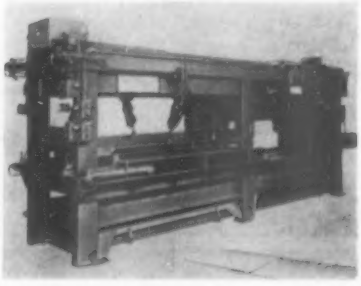
the electrodes can be driven by feed rollers found in all semiautomatic hardsurfacing welders.

The most important gains claimed for the new electrodes are high metal deposition, longer wear life of parts, and speed and ease of welding.

For additional details, write to American Manganese Steel Division, American Brake Shoe Co., Chicago Heights, Ill.

Strip Mill Welders

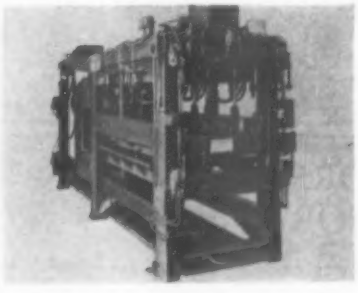
A recently developed and improved line of standard multispot welders for welding ends of steel coil stock in continuous strip mill operations is announced by Resistance Welder Corp., Bay City, Mich. These units join tailing end of one strip to leading end of next strip. Units are available for handling a wide range of steel strips up to a maximum width of 80 in.



Units are hydraulically operated and are furnished complete with hydraulic power unit and welding control equipment.

The traveling "C" frame carries two (2) or four (4) heavy duty mill type welding guns above the strip and two (2) or four (4) below the strip.

According to the manufacturer, units



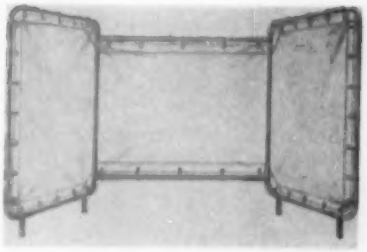
are designed for rapid traverse across the overlapped strip ends. Operator has full control over spot spacing. Guns will weld in either direction of the carriage travel, i.e., on the forward stroke or the return stroke of the carriage.

For complete details, write to Resistance Welder Corp. at above address.

Lightweight Portable Screen

A new lightweight portable screen has just been placed on the market. It is made of rust-proof tubular steel and according to its manufacturer, it assembles in a matter of minutes. Folds flat and compact, and because it weighs only a few pounds, it is easily portable. Can be used as a shield for welding or machine protection, or with special platform legs available, can be used as a wall in a straight line.

For further details, write to Special Products Division of Singer Glove Manufacturing Co., 860 Weed St., Chicago 22, Ill.



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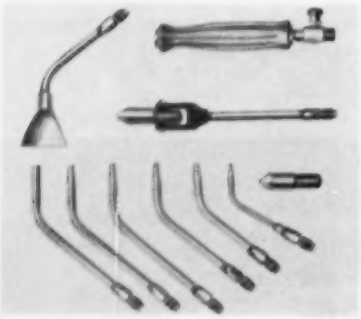
Soldering and Brazing Torch

Unusual versatility is the feature claimed for the Huber Model "A" soldering and brazing torch. This all-brass torch with form-fitting wooden handle is manufactured by Huber Industries, Inc., Cincinnati, Ohio. It is designed for use by electricians, plumbers, radio shops, refrigeration maintenance men, television and radio



repairmen, garages, body shops, jewelers, dental laboratories, painters and industry in general, wherever an adaptable tool of this type is required.

Ready to connect to an acetylene line, the model "A" has nine different tips which, according to the manufacturer, produce everything from a very fine flame to a broad burner. The unit also may be fitted with a soldering iron tip.

Further information about this practical item may be obtained by writing to Huber Industries, Inc., 4962 Hillside Ave., Cincinnati 33, Ohio.

Surfacing Electrodes

The Industrial Overlay Metals, Inc., Eaton, Ohio, have added to their alloy surfacing line a new manganese electrode using a 3½%-nickel, 13%-manganese base wire.

This electrode, known as Bergstrom Manganese 312, is available in either coated or bare. Its uses are the same as all manganese electrodes: welding, building up of hammer mills, crushers, railroad frogs, etc.

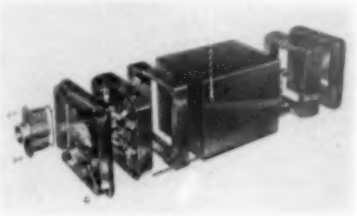
The company has also introduced another electrode, the Bergstrom 4-45, which is a high-carbon base wire with additional alloys in the coating. It is claimed to have excellent usability with no slag to remove. The numbers denote hardness. 4 Rockwell C as deposited, slightest impact causes surface hardness of over 45 Rockwell C. It is not machinable. The slight drag of the cutting tool is said to cause instant work hardening.

For complete details, write directly to Industrial Overlay Metals, Inc., Eaton, Ohio.

SUPPORT YOUR SOCIETY

Resistance Welding Transformer

Kirkhof Manufacturing Corp., 2450 Buchanan Ave., S. W., Grand Rapids, Mich., announces the manufacture and marketing of the new Kirkhof "Power-Pa'k" Resistance Welding Transformer.



The transformer is available in three basic models—Type AR, 50 kva, Type AT, 60 kva and Type AW, 70 kva. Special ratings are available on request.

The transformer is thoroughly factory tested and field proved and meets all JIC and RWMA, standards.

Complete details are available from the manufacturer on request.

BECKER

KEEN-ARC CARBONS

FOR CONSISTENTLY GOOD RESULTS

Designed to carry the high currents necessary for intense heat, BBB Keen-Arc Carbons produce a fine-grained weld of high tensile strength. They give a smooth, steady "flowing" flame which does not wander and which is concentrated at the desired focal point. Flame temperature is easily and accurately adjusted by merely changing the ampere input, and heavy copper coating permits gripping at extreme ends—eliminates frequent and periodic resetting.

A COMPLETE LINE OF CARBON WELDING SUPPLIES including carbon and graphite electrodes, carbon rods and plates, welding paste, etc. Write for catalog.

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No. 2 Brazing Flux
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No. 8 "ABC" Sheet Aluminum Flux
No. 16 Silver Solder Paste Flux.

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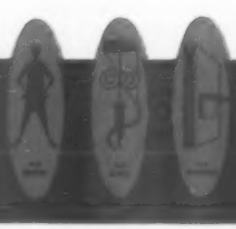
1. HOLD DOWN PRESSURE: 201,600 lbs.
2. METAL THICKNESS: .062 to .625
3. SEAM LENGTH: 28'
4. DIAMETER: 60" minimum, unlimited maximum or flat sheets
5. ACCEPTS conical or cylindrical shapes
6. SUBMERGED melt or gas shielded arc welding

EXTERNAL SEAMER

WRITE FOR PANDJIRIS CATALOG 8155

manipulators positioners weld-evators seamers head & tail stocks turning rolls



efficient positioning of all three

PANDJIRIS WELDMENT CO.

5151 NORTHRUP AVE., ST. LOUIS 10, MO., U. S. A.

NEW LITERATURE

First Specification Issued on Hard-Surfacing Welding Rods and Electrodes

Here, for the first time, is an authoritative source of information on welding rods and electrodes used for hard surfacing. The first specification (AWS A5.13; ASTM A399) covering these materials has just been issued by the AMERICAN WELDING SOCIETY and the American Society for Testing Materials.

Forty-five classifications of filler metal are established by this specification, including many of the commonly used surfacing materials. This involves the high speed steels, austenitic manganese steels, austenitic high-chromium irons, cobalt-base filler metals, copper-base and nickel-chromium-boron filler metals.

Of particular value is the Appendix, which is an invaluable aid to users in selecting the most suitable welding rod or electrode for their needs. It contains data on hardness, hot hardness, impact, oxidation and corrosion resistance, abrasion, machinability as well as information on many other properties.

Also included are two tables giving the chemical analyses of all the classifications.

Copies of this specification can be obtained at 40 cents each from the AMERICAN WELDING SOCIETY, 33 W. 39th St., New York 18, N. Y., or the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

ASTM Standards on Copper and Copper Alloys

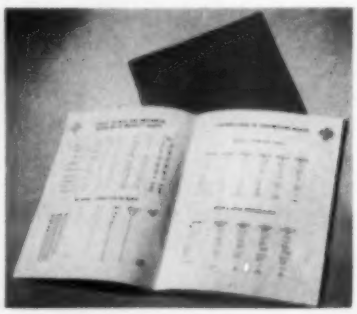
All of the ASTM Standards pertaining to copper and copper alloys, which were developed by ASTM Committee B-5 on Copper and Copper Alloys, Cast and Wrought, and related standards developed by Committees B-1 on Wires for Electrical Conductors and B-2 on Non-Ferrous Metals and Alloys, have been compiled into a compact, handy volume. The December 1955 edition of ASTM Standards on Copper and Copper Alloys includes in their latest form 127 ASTM Standards—110 specifications, 12 test methods, 2 recommended practices, 2 classifications (of coppers and copper-base alloys), and 1 definition of terms.

Standards cover copper, copper-alloy, and copper-covered-steel electrical conductors; copper and copper-alloy plate, sheet, strip and rolled bar; copper and copper-alloy rod, bar and shapes, and die forgings; copper and copper-alloy wire; copper and copper-alloy pipe and tube; copper-alloy ingot; copper-alloy castings; copper and copper-alloy filler metal; and methods of test for copper and copper-alloys.

Copies of this 654-page book can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa., at $5.75 per copy.

Resistance Welding Electrodes

A catalog of resistance welding products, accessories and materials was made available recently by Weldaloy Products Company of Van Dyke, Detroit, Mich.

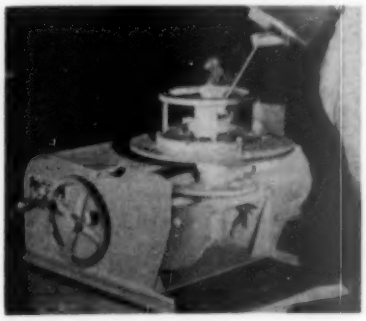


This literature describes and specifies standard and special spot-welding electrodes, seam-welding electrode wheels, dies, back-up bars, shafts and bushings. In addition, illustrated and specified in this catalog are Weldaloy water-cooled electrode holders, adapters, horn-clamp-holder assemblies and other accessories.

This catalog can be obtained by writing to Weldaloy Products Co., 11551 Stephens Drive, Van Dyke, Detroit, Mich.

Welding Positioner

Worthington Corp. recently made available a new specifications sheet on their power operated bench Model 1P welding positioner, which includes specifications, general description and photographs.



The Worthington Model 1P is designed for positioning small work in shops and educational or industrial laboratories.

According to manufacturer, variable speed drive table rotation and accurate worm-and-segment hand tilt facilitate welding, hard surfacing, assembling, repairing, grinding and similar operations by positioning work to the best advantage for the operator. Disengaging clutch provides free wheeling whenever desired.

For further information or copies direct requests to Worthington Corporation, Positioning Equipment Division, Plainfield, N. J., specifying Bulletin No. R-1700-814.

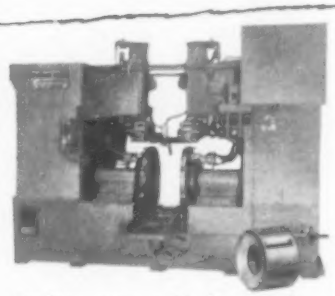
Flash Welding

Bulletin SP-15 describes resistance flash welding of components for aircraft and similar applications. The booklet includes illustrated examples of flashwelded landing gear, struts, control arms and rods and other minor assemblies. It outlines the advantages of flashwelding. Discussed are generally accepted destructive and nondestructive inspection and testing methods and required sampling frequency.

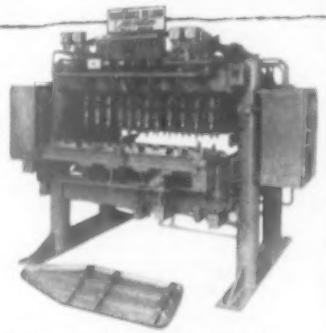
For your copy, write to The Taylor-Winfield Corp., Warren, Ohio.

Cost CONSCIOUS!

Do these examples of high production resistance welding and multi-purpose machines suggest a solution to a bottleneck in your production? . . . a cost reduction on your welded assemblies?

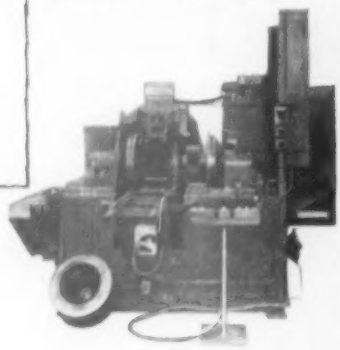


Machine seam welds front and back panels to Washer—Dryer Tub . . . automatically loaded and ejected . . . 100 per hour.



Shuttle type three (3) station multi-spot welder makes total of (60) spot welds on ironing board . . . 240 assemblies per hour.

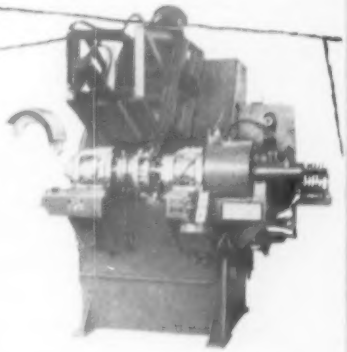
Multi-purpose unit rolls wrapper around front and back panels and makes (84) spot welds to form Washer Spinner Tub . . . (75) complete operations per hour.



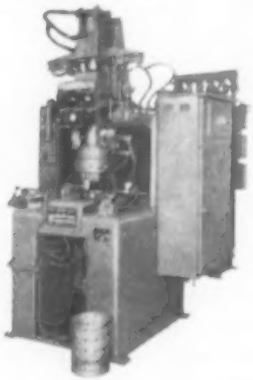
Rely ON RESISTANCE

for high production welding and allied equipments designed for a minimum of manual handling.

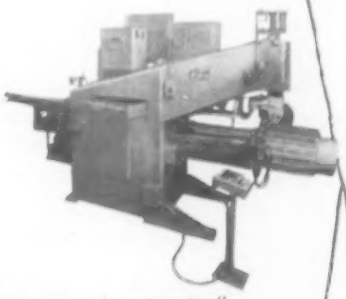
- ★ higher production
- ★ lower unit costs
- ★ uniform quality
- ★ save floor space and handling costs



Multi-purpose unit feeds and forms Brake Shoe Table to Web and simultaneously welds Table to Web . . . has interchangeable fixtures for single and double Web Shoes of various radii—600 per hour.



Unit gages, stretches and tack welds stainless steel Rings to form Jet Engine Components . . . close tolerances maintained.



Multi-purpose unit automatically feeds and roll spot welds cooling Fins to Power Distribution Transformer Tanks . . . tank is automatically indexed to position for each Fin . . . tank sizes vary.

- Complete line of standard spot, projection, seam and flash-butt welders.
- Special welding and multi-purpose machines.
- Complete automated production lines.

RESISTANCE WELDER Corporation
BAY CITY, MICHIGAN

AIRCO
WELDING and BRAZING Hints

PROBLEM:

To weld stainless steel

SOLUTION:

Airco Stainless Steel Rods. These rods are used principally in welding base metals of the same analysis. To a limited degree that may also be used for welding high strength and hardenable steels when such steels cannot be pre- or post-heated for welding. Stainless steel rods can also be used as filler metal in oxyacetylene welding.

Airco Stainless Steel Welding Flux. Due to its chemical action at welding temperatures, this flux liberates a gaseous envelope which tends to exclude the atmospheric oxygen. It thus reduces the formation of chromium oxides — adding to its superior qualities. This flux also dissolves any oxides present which would otherwise impair the welding. This same paste is ideal as a back up flux for the underside or inaccessible places that cannot be covered by inert gas for Heliwelding stainless steel.

Send for this free catalog!
You'll find here the finest rods and fluxes for joining both ferrous and non-ferrous metals. Write Airco at address below.

Request Catalog 9-13 WJ

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Offices and dealers in most principal cities
On the west coast—
Air Reduction Pacific Company
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Airco Company, International
In Cuba—
Cuban Air Products Corporation
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Air Reduction Canada Limited

Brazing Filler Rod

Ampco Metal, Inc., announces the release of a new Bulletin W-31 entitled, "Ampco-Braz #1 '3-in-1' Filler Rod," describing this new low-fuming, high-strength, nickel-brass rod for brazing and braze welding with the oxyacetylene process.

Included in this bulletin are sections covering the outstanding features of Ampco-Braz, #1, uses in industry and small shops, characteristics, deposit mechanical properties, etc.

Send direct to Ampco Metal, Inc., 1745 S. 38 St., Milwaukee 46, Wis., for Bulletin W-31 or pick up a copy from your local Ampco distributor.

Power Sources

The Lincoln Electric Co., Cleveland 17, Ohio, announces the availability of their Bulletin SB-1358, covering the Lincolnweld Power Sources. For your copy, write directly to Lincoln Electric Co. at above address.

Fluxes for Soldering

A new 4-page folder, "The Right Flux for the Right Job," that reportedly simplifies the proper selection of corrosive and noncorrosive fluxes for all metal joining from alnico to zinc, has been issued by the Anchor Metal Co., Inc., 244 Boerum St., Brooklyn 6, N. Y., a leading manufacturer of solders and fluxes.

Copies of the folder can be obtained free of charge by writing to Anchor Metal Co., Inc.

Welding and Cutting Equipment

Dockson Corp., 3839 Wabash Ave., Detroit 8, Mich., announces the availability of their new pamphlet on gas welding and cutting equipment and accessories.

Copies are available by writing directly to Dockson at above address. Ask for form 56-05.

Aluminum Handbook

One of the most comprehensive reference handbooks on aluminum ever to be compiled has been made available to industry by Aluminum Company of America.

Entitled the "Alcoa Aluminum Handbook," the new booklet provides an up-to-date successor to the now discontinued "Alcoa Aluminum and Its Alloys."

Following a theme of conciseness and convenience, the 176-page book presents data on aluminum alloys and mill products in an easy-to-read tabular form. There is little text.

This book contains information on alloy standards as well as the properties, sizes and tolerances of mill products usually produced from them.

The introductory section explains the code numbering system employed to designate alloys and their modifications.

Copies of the "Alcoa Aluminum Handbook" are available by writing on a company letterhead to Aluminum Company of America, 781 Alcoa Building, Pittsburgh 19, Pa.

Let's Get Down to Facts About CLAIMS—

Yes, we could run a full page telling you why our Products are better, but we prefer to have

HI-AMP
ELECTRODE HOLDERS

prove their advantages by actual test with others —that's why we say, ask your Dealer to demonstrate a HI-AMP and you'll "see" why Welders everywhere prefer it.

LENCO, INC.
(Formerly Wagner Mfg. Co. Inc.)
JACKSON, MISSOURI

Weld with HI-AMP

Gas Welding Equipment

Modern Engineering Co., St. Louis manufacturer of MECO oxyacetylene welding and cutting equipment, has announced the 1956 revision of its No. 150 General Welding Catalog covering its complete line of oxyacetylene welding and cutting torches, machine cutting torches, regulators, pressure gages, hose connections, couplings and safety equipment.

Copies of the catalog and price lists may be obtained free of charge by writing: Modern Engineering Co. Dept. 354, 3407 Pine Blvd., St. Louis 3, Mo.

IDEAS!

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PUBLIC HALL
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More than 100, idea-packed technical papers will be presented by experts.

You'll learn cost-cutting ideas for every phase of metals thinking from product design to product test. You'll see all the modern ideas in heat treating, fabricating, cleaning, finishing, machining, foundry, forging, testing, welding, inspection.

You and the management, engineering, production and purchasing men you work with will earn and learn much more than the cost of your visit to this great Metal Show. It will be just like touring 500 plants in the metal industry, which would otherwise take months of your time.

Plan now to attend with a team from your plant. The hundreds of profitable product and technical ideas you and your associates will take home will be just what you need in your future planning.

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PUBLISHERS

Metal Progress
Metals Review
Metals Handbook
ASM Transactions
Metal Showmen
Technical Books

Automatic Welding Head Manipulator

Worthington Corp. recently made available a new bulletin on their automatic welding head manipulator, Mast Type (10 x 12), which includes specifications, general description, special features and other important data.

For further information or copies address requests to Worthington Corp., Positioning Equipment Division, Plainfield, N. J., specifying Bulletin No. R-1700-B18.

Welding of Plastics

A new issue of its bi-monthly external house organ, the "Plastics Weldor and Fabricator" has just been released by the American Agile Corp., Maple Heights, Cleveland, Ohio.

The issue highlights an illustrated article entitled "New Horizons in Plastic: Containers," which describes various types of containers of plastic, their advantages and applications.

Another in the regular series "Tips on the Hot Gas Method Of Gas Welding" is likewise included.

Copies of the free literature may be obtained from the American Agile Corp., P. O. Box 168, Bedford, Ohio.

Head and Eye Protection

The Dockson Corp., 2839 Wabash Ave., Detroit 8, Mich., has available a new illustrated folder describing about thirty of the most popular items in their complete line of Head and Eye Protection Equipment. The folder includes goggles for welders and chippers, plastic eye savers, spectacle-type goggles, eye shields, welders' helmets, masks, hats and lenses.

Electronic Welder Control

Sciaky Bros., Inc., 4915 W. 67th St., Chicago, Ill., introduces Bulletin 339, completely describing a four-function spot welder featuring Sciaky's new Predetermined Electronic Welder Control to cover a wide range of aircraft and other rigid welding specifications.

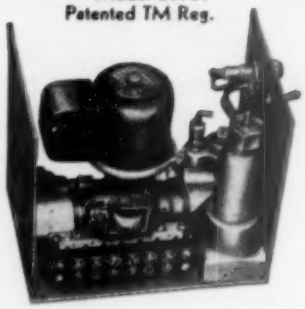
This bulletin reveals the various circuits employed with this new type dekatron tube control. With the assistance of various illustrations and a block diagram, the four-function spot welder is simply and effectively explained.

For your free copy of Bulletin 339, write to the above Chicago address to the attention of Dept. L-11.

WATER MIZER

Model ET101

Patented TM Reg.



Water is Scarce! Why Waste It?

WATER MIZER saves water—and money, too. Here is a typical example how WATER MIZER controls cooling water on resistance welders and saves up to 80% on consumption. Data below is from an actual production job test in a well-known factory.

BEFORE INSTALLATION

8 hour work day
8 hours of water flow
2960 gallons used

AFTER INSTALLATION

8 hour work day
1½ hours of water flow
495 gallons used

WATER MIZER pays its way in a short time. Satisfied users report very little servicing necessary. Ask for data on units for resistance welders, for induction heating, for hydraulic systems.

VAN VOOREN PRODUCTS

2133 Ninth St., East Moline, Illinois

Territories Open for Distributors

Detergent-Action Safety Solvent

A new four-page folder describing Turco-Solv, a detergent-action safety solvent, has been issued by Turco Products, Inc.

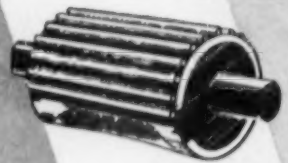
The folder states that while Turco-Solv is designed primarily for the in-place cleaning of electrical equipment, it is also ideal for the hand wiping of small parts, for precleaning prior to flaw-detecting operations, for grease pencil, chalk or ink removal, as well as a host of other cleaning jobs incident to plant maintenance.

According to manufacturer, the compound is nonconductive, evaporates to complete dryness without leaving a residue, requires no rinsing, and is safe on all metals, paint and varnishes.

A free copy of the folder (A-28) may be obtained by writing to the manufacturer, Turco Products, Inc., 6135 S. Central Ave., Los Angeles 1, Calif.

FASTER..

than drop-by-drop buildup methods!



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11%-13½% MANGANESE-NICKEL STEEL

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- Cost less and give longer service than new crushers
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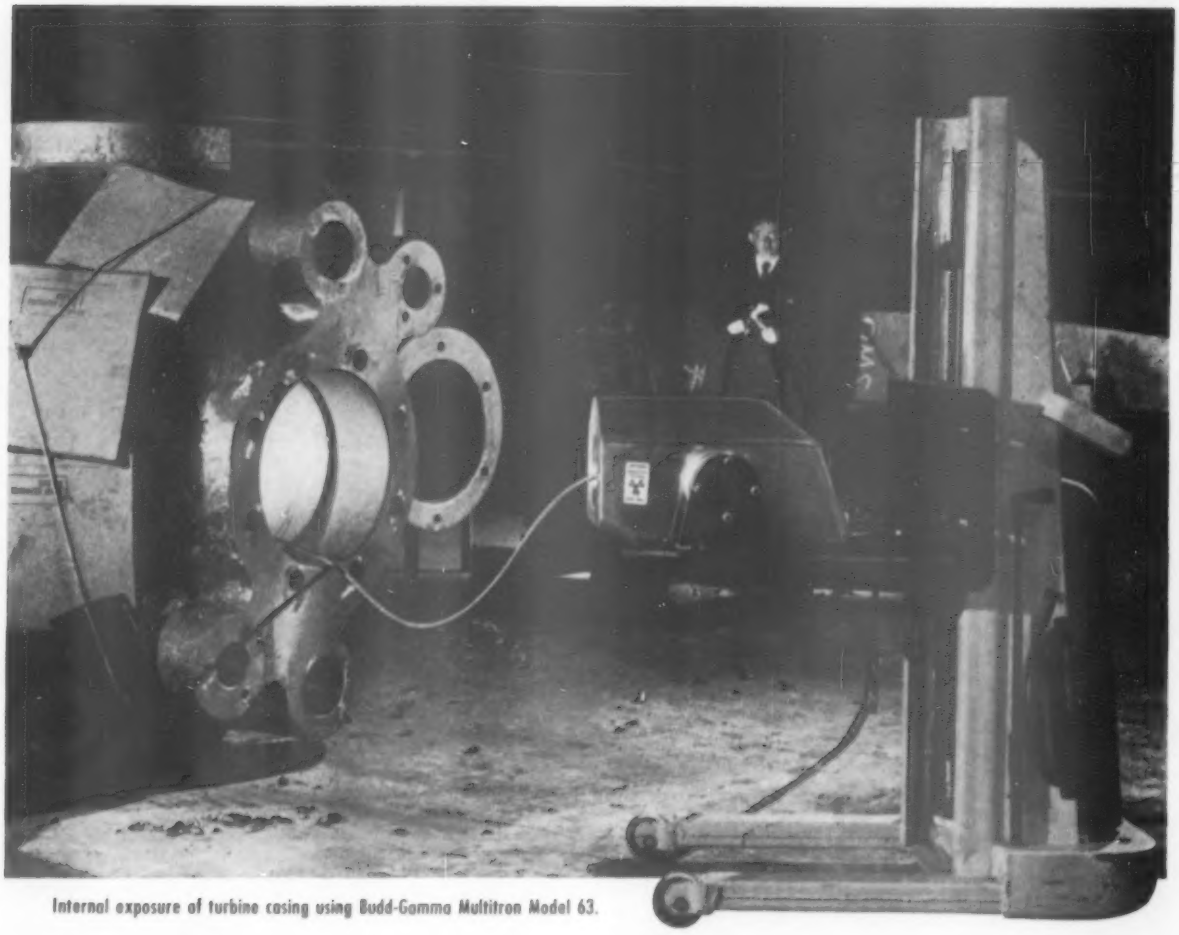
IN CLEVELAND



Internal exposure of turbine casing using Budd-Gamma Multitron Model 63.

Budd provides complete Gamma Isotope Radiography Service

The physical and technical resources of The Budd Company are now being directed to the development and manufacture of gamma isotope radiography units.

These units are designed to employ any of the established gamma ray sources, of any required strength, and to provide for panoramic, beam and internal shots.

They are portable and can be operated by one man. They require no attachment to electrical or water lines, consequently they can be used anywhere. They are fast. Accurate. Economical. Safe.

Budd will train your operating personnel in the use of these devices, and also provides a service for the replacement of gamma sources at scheduled intervals.

For catalogue and complete information, address The Budd Company, Gamma Division, Philadelphia 32.

Budd

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FOR ALL HEAT-DEPENDENT OPERATIONS

looks like a crayon... marks like a crayon... tells temperatures like a precision instrument!

Available in these Temperatures (F.)		
113	375	1000
125	388	1050
138	400	1100
150	413	1150
163	425	1200
175	438	1250
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200	463	1350
213	475	1400
225	488	1450
238	500	1500
250	550	1550
263	600	1600
275	650	1650
288	700	1700
300	750	1750
313	800	1800
325	850	1850
338	900	1900
350	950	1950
363		2000

Sixty-three different compositions enable you to determine and control working temperatures from 113° to 2000° F.

TEMPILSTIK° marks on workpiece "say when" by melting at stated temperatures — plus or minus 1%.

ALSO AVAILABLE IN LIQUID AND PELLET FORM . . . WRITE "WELDING SALES" DEPT. FOR SAMPLE TEMPIL° PELLETS . . . STATE TEMPERATURES OF INTEREST—PLEASE!

Tempil° CORPORATION 132 WEST 22ND STREET, NEW YORK 11, N. Y.

Visit us at Booth 929 October 8–12 National Metal Congress—Cleveland

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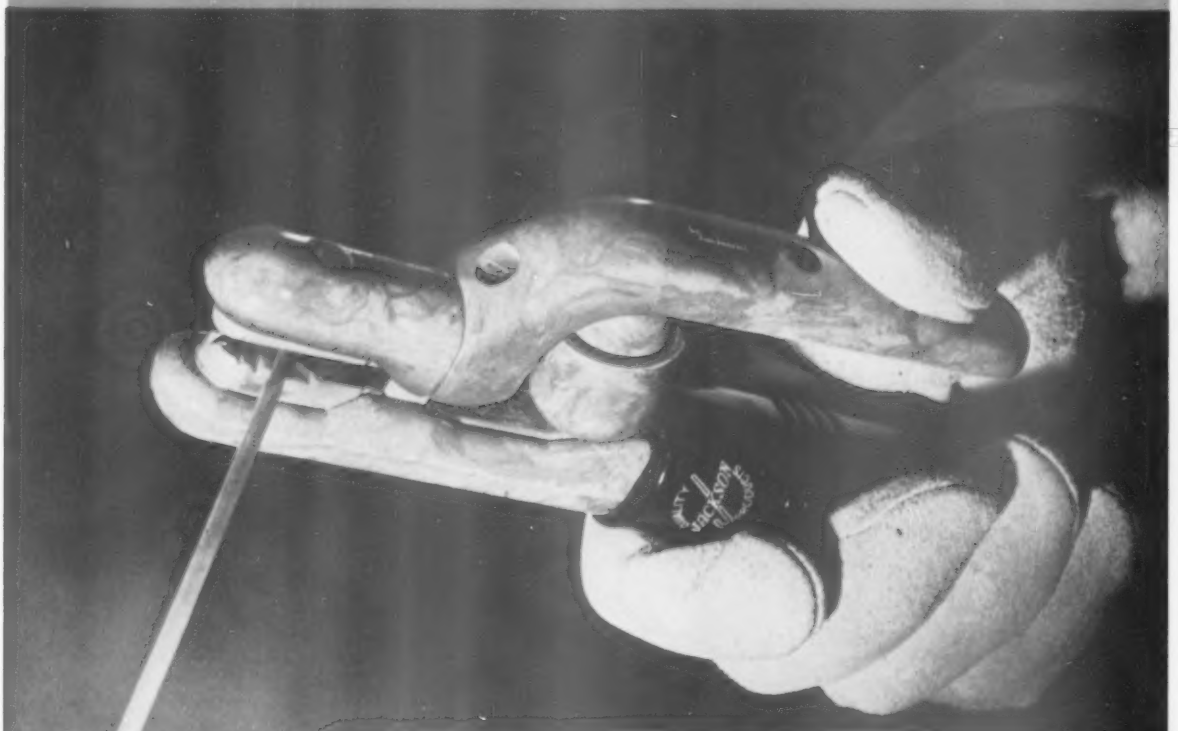
Quality Wins Out



Jackson's fully insulated, safe arc welding electrode holders have been made since 1934. More than 2½ millions have been sold.

Progress, through constant research, resulted in the best alloys for the tongs, the most durable fiber glass plastic for the insulation.

Model A-W, shown here, the world's most popular, exemplifies the high standards of quality maintained by Jackson Products.

Jackson Electrode Holders, Ground Clamps, Cable Connectors, Splicers and Lugs
Jackson Safety Hats, Welding Helmets, Goggles and Eyeshields
Sold World-Wide through Distributors and Dealers

JACKSON
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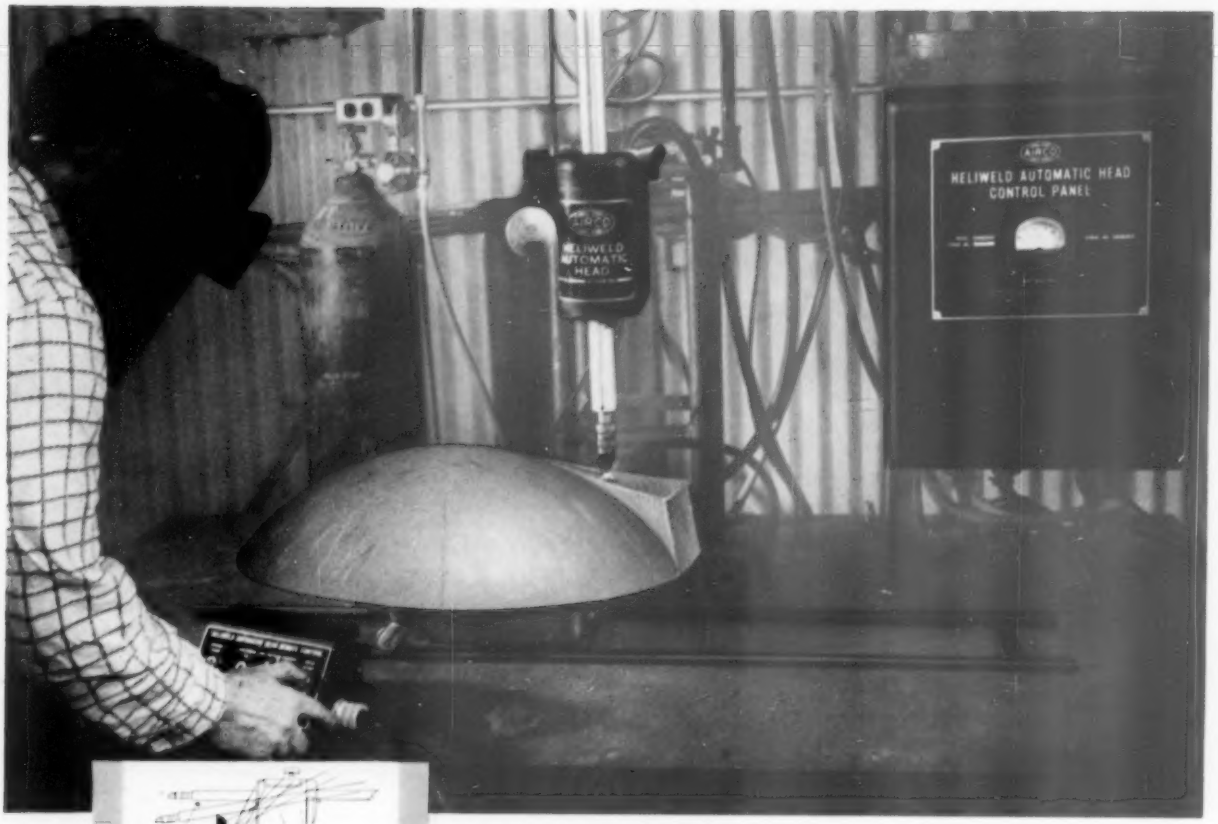
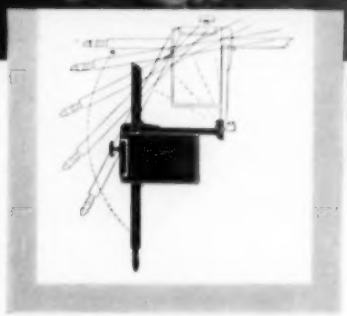
WARREN-MICHIGAN





New Airco Model C Heliweld automatic head operates at all angles from horizontal to vertical.

Airco introduces New Automatic Heliweld Head for long-run production welding

The Model C Heliweld automatic head is specifically designed for long-run production on regular or irregular contours — aluminum tubing, motor stators, irregularly-shaped pressure vessels. Its prime advantage is that once the required arc length is set the head will automatically maintain this distance by moving the holder up or down to follow the contours of the work piece. Other benefits are:

- **Versatility** — unit provides good arc voltage control using either argon or helium shielding gases or mixture of both.
- **Adaptability** — the head can be operated at all angles from the horizontal to the vertical (normal) position. The maximum raise-lower distance of the electrode holder is a full 16".
- **Flexibility** — the assembly can be used for AC or DC welding, with or without filler wire. Electrode diameters range from .020 to ⅛".

The use of the new automatic head will be required where welds of consistent dimensions and quality are important and where good weld appearance is necessary or where welding specifications are very high for the electrical, aircraft, and refrigeration industries. Complete information covering the wide range of applications and detailed specification data is available. Write Airco at the first opportunity.

AT THE FRONTIERS OF welding PROGRESS YOU'LL FIND . . .

AIRCO

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AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated, New York 17, N. Y.

On the west coast — Air Reduction Pacific Company

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In Canada — Air Reduction Canada Limited

Products of the divisions of Air Reduction Company, Incorporated, include: AIRCO — industrial gases, welding and cutting equipment, and acetylenic chemicals • PURECO — carbon dioxide, liquid-solid ("DRY-ICE") • OHIO — medical gases and hospital equipment • NATIONAL CARBIDE — pipeline acetylene and calcium carbide • COLTON — polyvinyl acetates, alcohols, and other synthetic resins.